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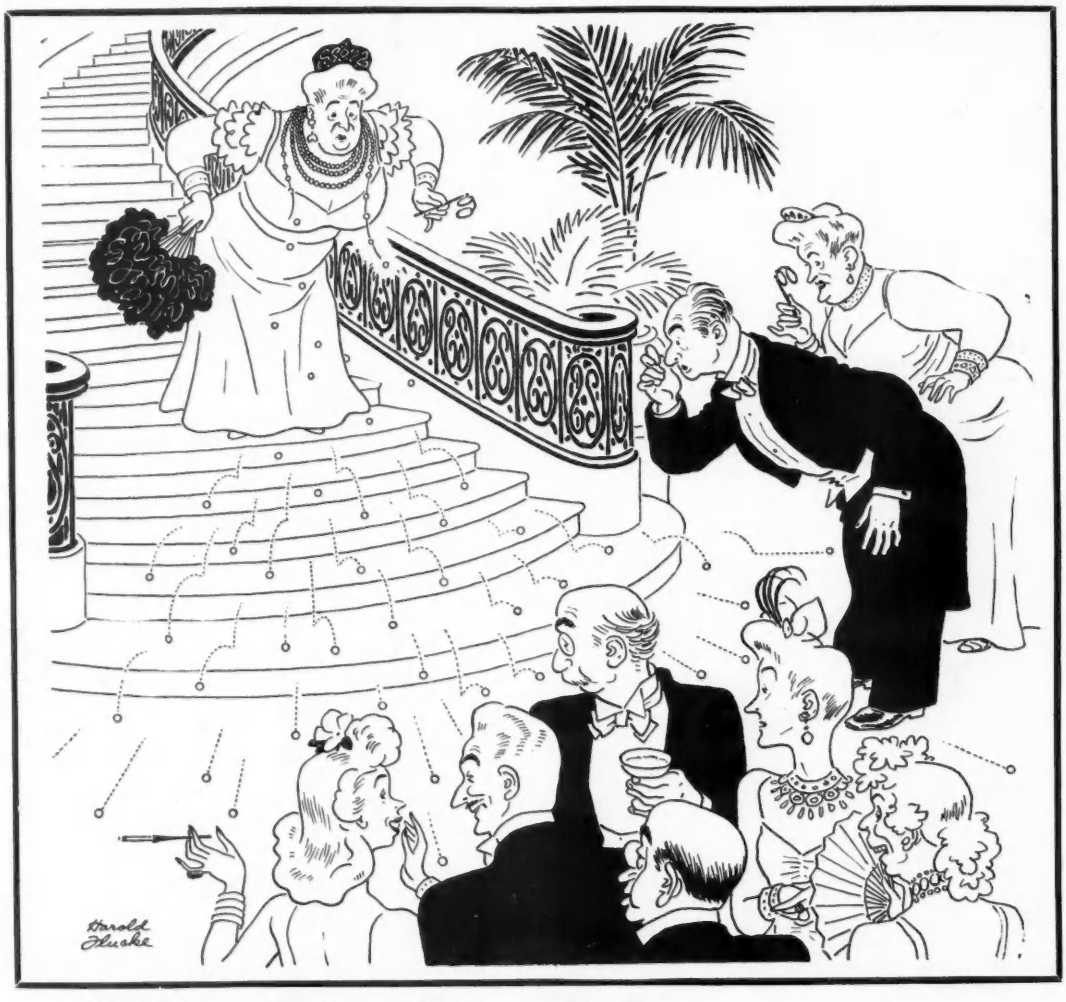
AUTOMOTIVE and Aviation INDUSTRIES

MAY 1, 1945



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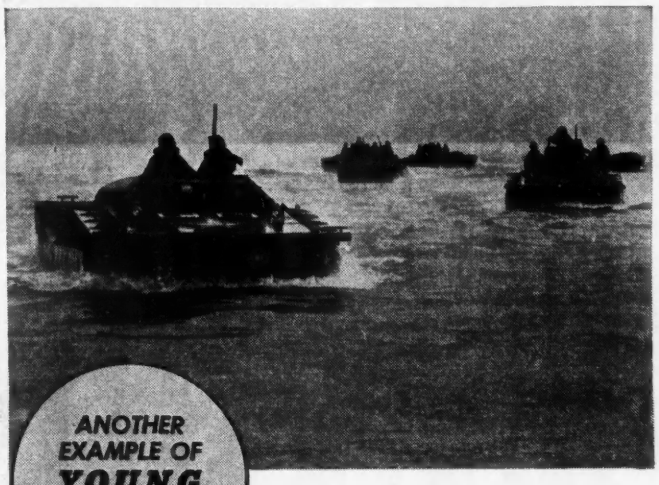

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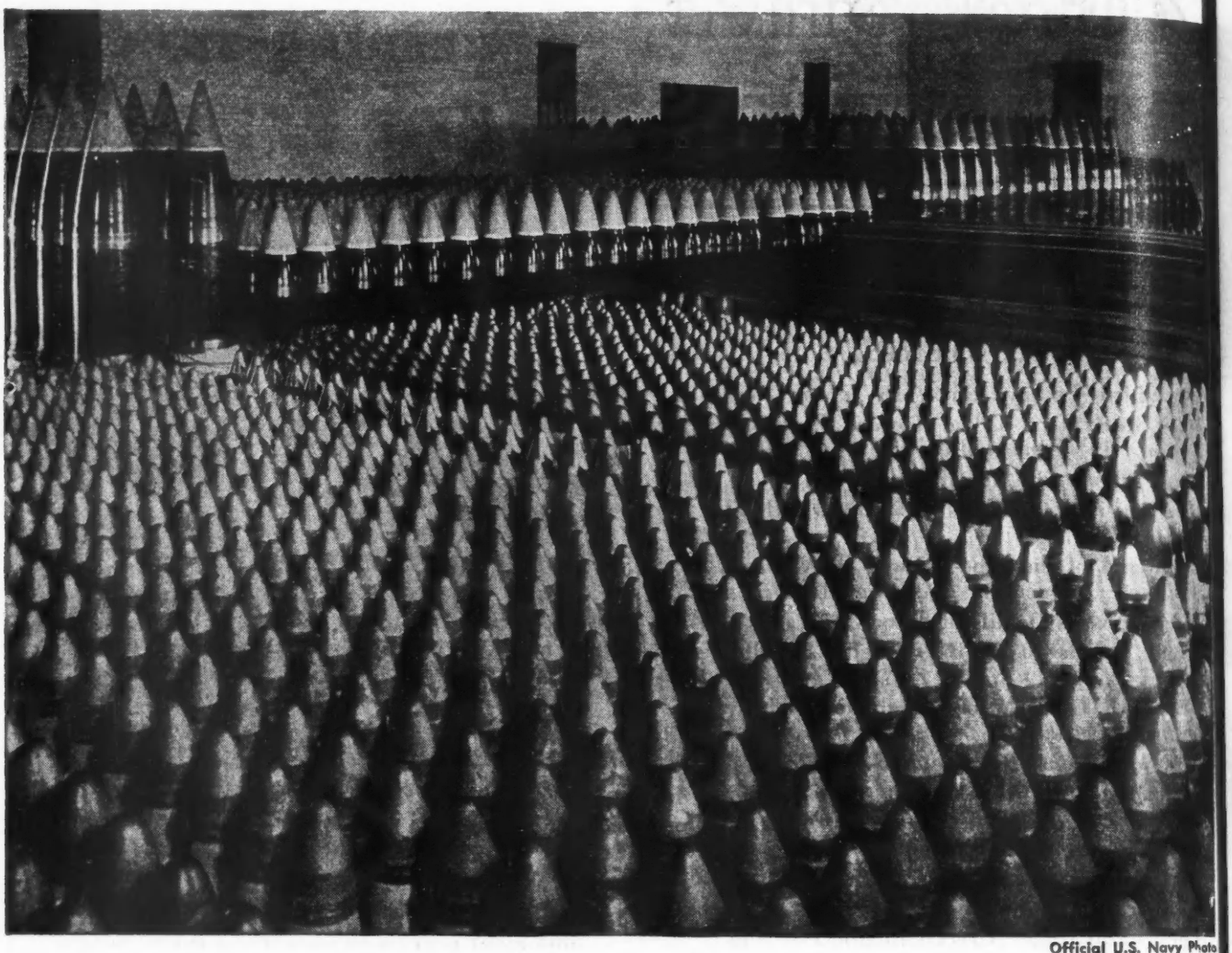

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IN THE first 30 months of the war, the U. S. Navy alone fired more than 41,000 tons of projectiles at the enemy! Each of these projectiles — from machine-gun bullets to giant 16-inch shells — had to be finished to the most precise tolerances for safety and accuracy in firing.

Because ammunition is needed in such vast quantities, machining must be fast as well as accurate. Texaco Cutting and Soluble Oils not only assure faster machining, but better finish and longer tool life as well. That is why they are the choice of experienced machine tool operators everywhere.

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AUTOMOTIVE and AVIATION INDUSTRIES

Published on the first and 15th of the month

May 1, 1945
Volume 92, No. 9

To Which We Say, Amen

by Julian Chase

IN THE history of the United States of America another chapter begins. What will actually be written in it is largely anyone's guess. What different and divergent groups among us will strive for is already on the record.

After many years of ascendency for leftist advocates of radical economic reform, it is not too much to hope that the time has now arrived not only for the squelching of that type of pseudo reformer, but also and concurrently for encouragement of individual initiative and for reform in our national politics.

Winston Churchill in his recent talk before his own political party, set up some simple principles which might well be adopted here. He promised that "There is one thing we shall certainly not do. We shall not bid for votes or popularity by promising what we cannot perform, nor shall we compete with others in electioneering baits and lures."

What he said about embryonic economic reforms can also be read here with profit. No comment is necessary. The quoted extracts are sufficient.

"We have no use here for totalitarian schemes of government in their various forms. Our Socialist friends have officially committed themselves to a program for nationalizing all means of production, distribution and exchange. These are all matters which the public can consider . . . when our soldiers are home again. Then will be the time to go into all these sweeping proposals which imply the creation and enforcement of another system or systems borrowed from foreign lands and alien minds.

"You hear all this talk by the stay-at-home left wing intelligentsia that the soldiers will hold us guilty if we do not have a new world already waiting for them. But that is not what the fighting men are looking forward to. They are not looking forward to a new world constructed behind their backs by politicians who seek their votes. . . . They do not regard themselves as slum-bred serf population chased into battle from a land of misery and want. They love their country and the scenes of their youth and manhood and they have shown themselves ready to die, not only in defense of its material satisfactions but for its honor.

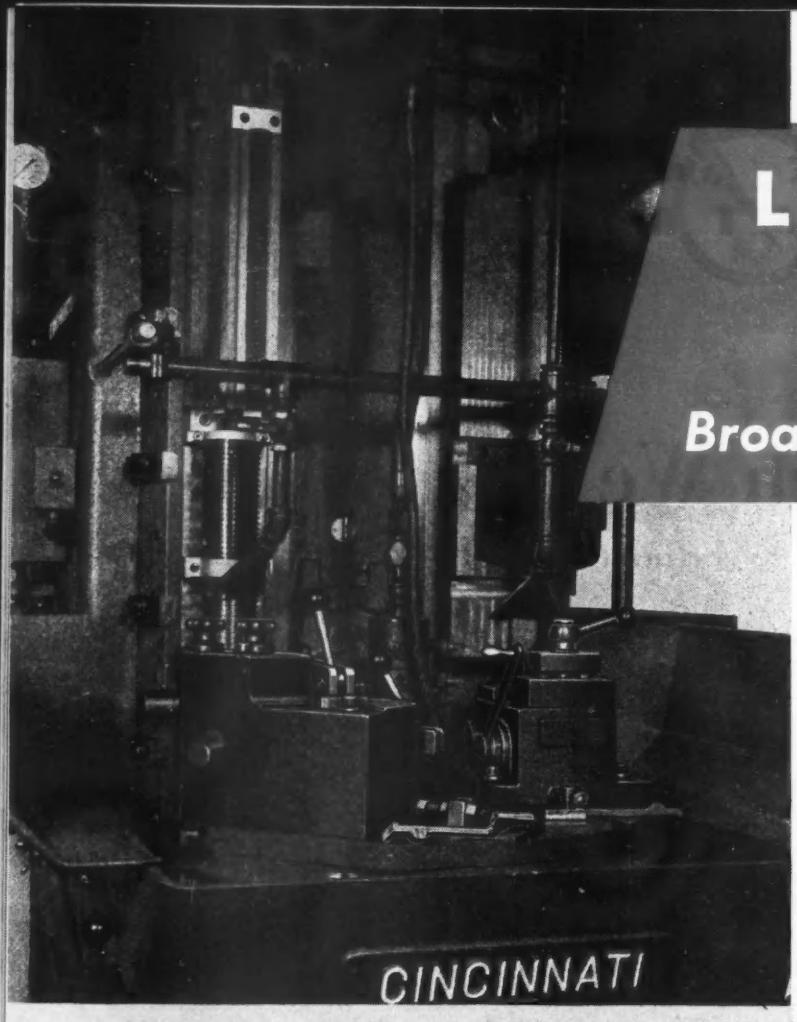
"If we are to recover from the measureless exertions of the war it can only be by a large release from the necessary bonds and controls which war imposed.

"Control for control's sake is senseless. Controls under the pretext of war or its aftermath which are, in fact, designed to favor the accomplishment of totalitarian systems however innocently designed or whatever guise they take, whatever liveries they wear, whatever slogans they mouth, are fraud which should be mercilessly exposed. At the head of our mainmast we fly the flag of free enterprise. We are determined that native genius and the spirit of adventure and of risk taking, in peace as in war, shall bear our fortunes forward . . . and that good, thrifty housekeeping, both national and private, shall sustain our economy."

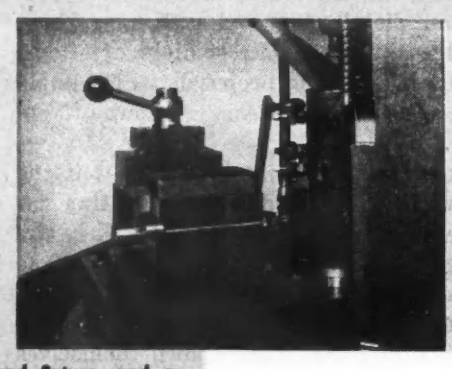
To all of which we say, So mote it be, both there and here.

LEFT HAND STATION

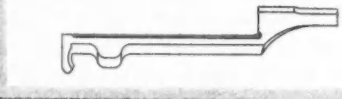
Handles Two Broaching Operations

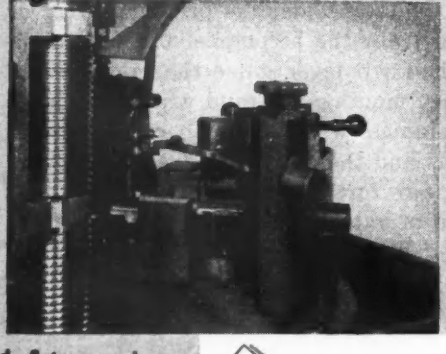


Close-up of the machine and equipment for three broaching operations on operating rod handle—a chamfered surface in the right-hand station, and a 2" radius and a flat surface in the left-hand station.



The right-hand fixture, and a drawing of the part showing the surface broached — 45° chamfer and 3/32" radius.





The left-hand fixture and a drawing of two parts in correct relation to each other for their respective broaching operations.

Combining cuts is an old story in screw machine and turret lathe work, but here's a case where it has been applied to broaching. Three operations are handled on the equipment illustrated... a CINCINNATI No. 5-54 Duplex Vertical Hydro-Broach tooled up by CINCINNATI Application Engineers.

In the right hand station one surface is broached—a 45° chamfer—while the left hand station accommodates two broaching operations. The two-operation fixture holds two parts. A 2" radius and a flat surface are broached to blend with each other on the part in the upper station, while a flat and a short radius on the opposite side of the part is broached in the lower station. The machine and its equipment handles the three broaching operations at the rate of 142 completed parts per hour.

This is another example of the possibility of broaching parts which are manufactured in comparatively modest quantities, and do not warrant a machine for each operation. Perhaps the idea could be applied to many parts in your own shop. Our engineers will be glad to talk to you about your machining problems.

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TOOL ROOM AND MANUFACTURING MILLING MACHINES...SURFACE BROACHING MACHINES...CUTTER SHARPENING MACHINES

First *Real Steps Taken Toward* Reconversion

By Leonard Westrate

FOR the first time since reconversion planning came out into the open last summer the automobile industry is optimistic about Governmental action in clearing the decks for resumption of automobile production when and if the signal is given sometime soon after V-E Day. This does not mean that all of the problems have been licked or even that any astounding progress has yet been made. It does mean, however, that the recent action of War Production Board Chairman J. A. Krug and his special task force headed by Henry P. Nelson in slashing red tape expediting delivery of $50 million worth of critically needed machine tools and assigning high priority to reconversion construction, dies, jigs, fixtures and other equipment is a significant step forward. The same priority assistance applied to parts makers who demonstrate need.

Cars Off the Line Three Months After Go-Day at Earliest

In view of the rapid train of events involving military advances and contract cutbacks which are beginning to come in, the situation is increasingly apparent that it already is very late to be getting started on reconversion steps. Men in the automotive industry say that practically no advantage will accrue from the long delay in V-E Day since almost nothing has been done since the military setback in Belgium last fall and that it still will take from a minimum of three months for some companies to as high as nine months for others to get into car production. Most optimistic prediction, assuming that V-E Day occurs by June 1 and that there are no bottlenecks, is that the first car will come off the line by Sept. 15 at the earliest. It is safe, however, to predict that there will be some cars made by Thanksgiving if V-E Day comes by early summer, according to industry spokesmen.

The machine tool situation still remains No. 1 problem in the industry. Before the war the car manufacturers were using about 170,000 machine tools. After Pearl Harbor all companies released for use by all industry those machines not needed in their plants for war work. This accounted for a loss of about 12,000 machines and several thousand more were so altered for special war use as to be unrecoverable for their original purpose. At present in the automobile industry about 150,000 privately-owned machine tools are tied up with war work. At least two-thirds of these must be freed in addition to the new tools which WPB is helping make available before car production can be resumed on a partial basis.

Under new regulations the fewer than 5000 critically needed new machine tools will carry an AA-3 priority rating, second only to military orders. This is the first implementation of Krug's promise to get within the next four or five months the tools the industry needs. The automotive orders will be wormed into the machine tool makers schedules at the earliest possible moment, even to the point of displacing some military orders which may be deferred to a later delivery date without tampering the war effort. In cases where a satisfactory delivery date cannot be set, the manufacturer will appeal to his regional WPB Office and a special WPB expeditor will take any necessary steps to get the machine. It is reported that although some machines will require six or seven months to build after being put on the schedule, it may be possible in case of emergency to divert such machines from a military order, but again only if the war effort is not impeded.

The outlook for repossessing company-owned machines from war work and buying surplus tools is not so encouraging. Previous experience in this respect has been bad. Industry has had promises from the various contracting agencies for more than a year that something would be done to substitute idle Government-owned machines for company-owned tools on war work, but so far nothing more than talk has re-

(*Turn to page 62, please*)

Gas Turbines

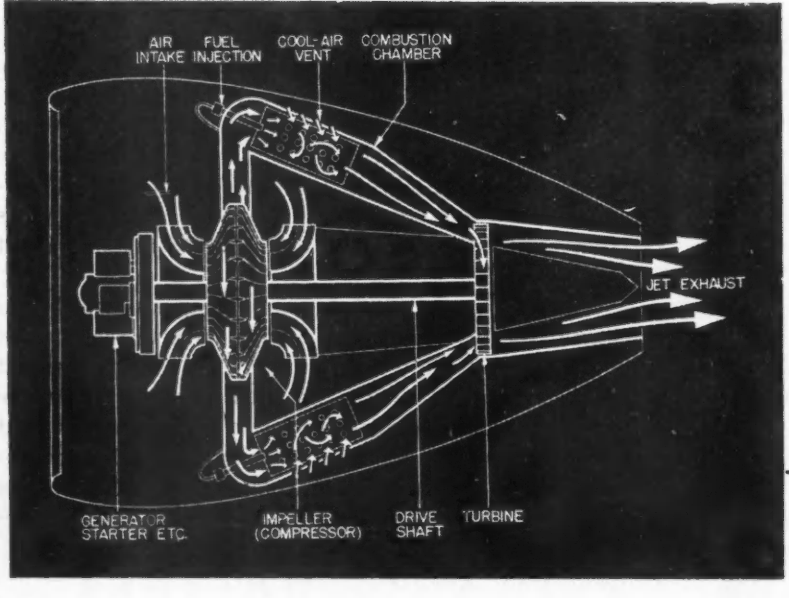
IN A paper read recently in London before the Royal Aeronautical Society, Air Commodore F. R. Banks, Director of Engine Development at the Ministry of Aircraft Production, gave a comprehensive review of the problems and prospects of the gas turbine for aircraft propulsion. It is his opinion that the gas turbine has not only come to stay, but is bound to take the place of the piston engine for many applications. The gas turbine will be so competitive in five or ten years, he predicted, that the large piston engine may not survive; the smaller piston engine will also have a hard fight to exist.

The speaker discussed some of the great developments in piston engines during the past 25 years, such as the sodium cooled poppet valves, the sleeve valve, lead-bronze and silver-lead bearings, variable pitch and constant speed propellers, the supercharger, high octane gasolines and alloy metals, which have made possible high output, low weight engines with moderate cylinder size. As an example he mentioned one engine that in eight years had its maximum power doubled from 0.5 to 1.0 bhp per cu in. piston displacement and 3.1 to 6.2 bhp per sq in. of piston area. As to aircraft engines of the future, Air Commodore Banks believes that the reciprocating engines will not be feasible in unit sizes above 6000 hp because of installation and propeller problems.

The principal disadvantage of the gas turbine, in the opinion of Air Commodore Banks, is its high fuel consumption. For this reason alone, the piston engine will remain in the picture until more is known about the operating economy of the gas turbine and the particular design of aircraft required for it.

A great advantage of the gas turbine is the speed at which it can be evolved. It takes about one-third of the time to design and build a prototype turbine of the simple "jet" type as to design and build a new piston engine of comparable power. Even the more complex turbine types and those having propellers should take only about half the time of the equivalent piston engine to build. About six months is required to design and build a simple turbine of the jet type in prototype form, and approximately an additional 12 months to put it into production—18 months in all as compared with four years for the piston engine. Furthermore, the simple turbine jet unit is about one-third of the weight of the piston engine, power for power, and its installed weight is little more than its dry weight; it does not have a radiator and coolant, and only a small quantity of lubricating oil is necessary for its operation. An oil cooler is not required when ball or roller bearings are used instead of plain bearings.

The smoothness of operation of the gas turbine, whether used in jet form or with a propeller, is such that the airframe will need less maintenance than with a high output piston engine installation.

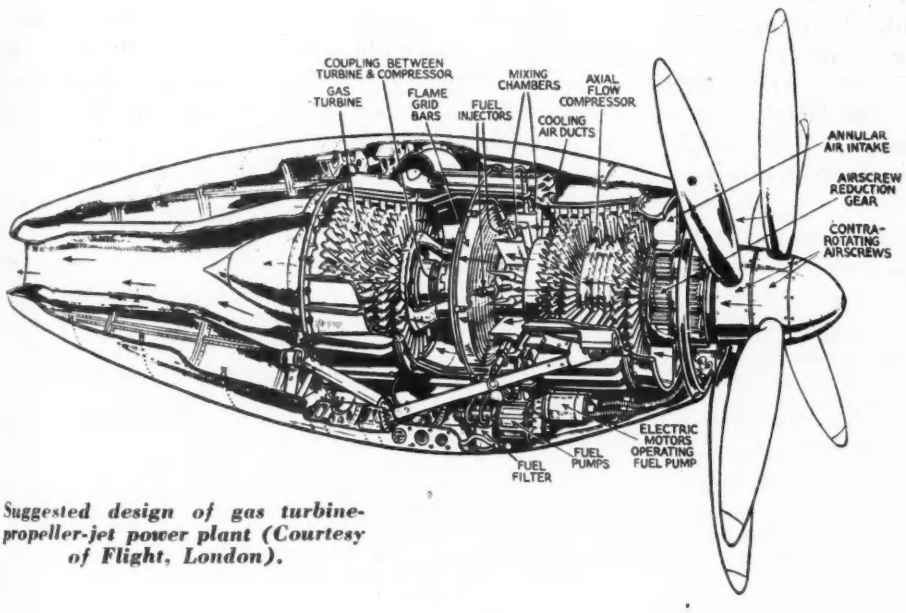


Schematic diagram showing cycle of gas turbine-jet engines in American and British jet-propelled airplanes, the twin-engined Bell P-59A Airacomet and single-engined Gloster, respectively. General Electric Co. is producing the Airacomet engines, developed from the British Whittle design. Advanced types of these turbo-jet engines also are being built by General Electric and the Allison Division of General Motors for the single-engined P-80 Shooting Star, which is being manufactured by Lockheed and North American. The thrust power delivered by the new GE turbo-jet engine used in the P-80 is said to be more than twice the power of the P-59 engine. In England the Gloster Co. is producing a new model, the Meteor, a twin-engined jet-propelled plane.

As shown in the diagram, air enters at the front of the engine and is compressed by the high speed (up to 20,000 rpm) impeller to about four times atmospheric pressure and then is charged into the combustion chambers consisting of a series of burner tubes radially spaced around the drive shaft. Fuel is injected at high pressure and an air/fuel ratio of 60 to 1 into the combustion chambers where it is burned to create high pressure gases that drive the turbine wheel. Turbine bucket temperatures go as high as 1800 to 2000 F. Thrust is thus produced by the reaction from converting the high pressure energy into a blast of high velocity gases.

for Aircraft Propulsion

British Director of Engine Development Surveys Problems and Prospects



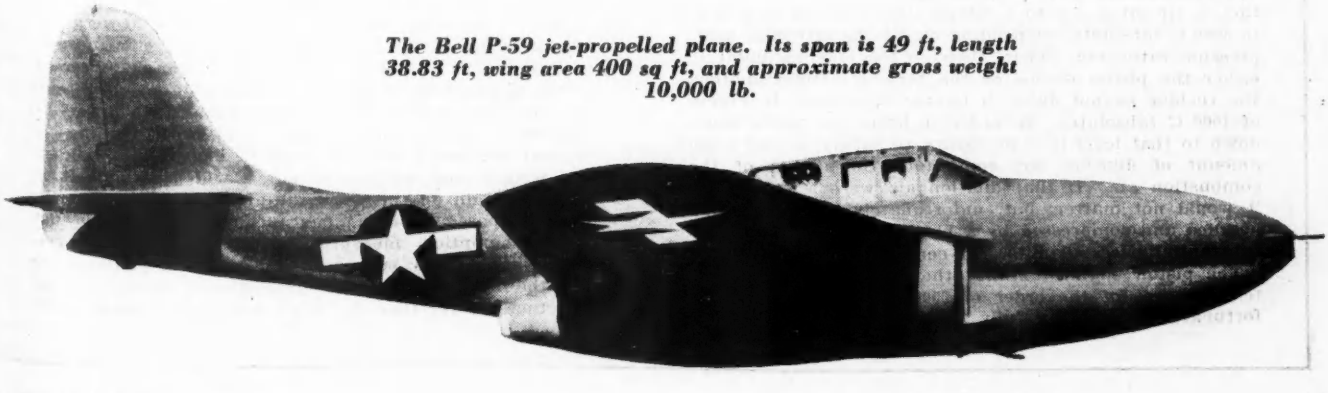
Suggested design of gas turbine-propeller-jet power plant (Courtesy of Flight, London).

The gas turbine can be built in a number of different forms. One is the original and classic Whittle type with a single-stage blower and single-stage turbine, and operating as a pure jet. Another form, working on similar principles, uses a multi-stage, axial blower with a turbine wheel. Both of these types, axial and centrifugal, can be arranged to drive a propeller through double-reduction gearing by suitably proportioning the blower to the turbine. There are also turbine-propeller combinations using axial and centrifugal blowers in series to gain a higher pressure ratio and improved economy. Still other blower and staging arrangements are possible as, for example, the turbine with augmenter. This is really a turbine-type fan in an annular duct surrounding the main turbine, usually connected to a ring of turbine blades located in the gas stream of the turbine proper. This augments the main jet stream and is virtually a "half-way house" between the simple jet and the turbine-driven propeller. These various combinations will be tried in the near future and we shall then know something of their relative merits.

The basic difference between the turbine-jet and the turbine-propeller arrangements is that the simple jet produces all its available power in the form of exhaust-jet energy, the exhaust gas being ejected as a relatively-small-diameter, high-velocity stream (about 1600 fps), the reaction of which propels the aircraft through the air. On the other hand, the turbine-propeller arrangement uses about 80 per cent of the available turbine power to drive a normal propeller, the remainder being employed in jet form. The figure of 80 per cent is chosen arbitrarily to illustrate this case, but the division of power as between propeller and jet can be arranged to suit any particular operating condition.

In the case of both the turbine-jet and the turbine-propeller, the propulsive effect is highest when there is least difference in speed between their respective gas discharges and the speed of the aircraft in which they are fitted. This assumes that efficiency is assessed on a change of kinetic energy basis; where

The Bell P-59 jet-propelled plane. Its span is 49 ft, length 38.83 ft, wing area 400 sq ft, and approximate gross weight 10,000 lb.



input per pound of air flow is equal to the jet kinetic energy less the kinetic energy of forward speed.

It is difficult to estimate what the operating economy of a gas turbine will be in flight from fuel consumption figures obtained on the test bed since at altitude it is run under conditions which cannot yet be exactly simulated on the test bed at sea level, and under "static" conditions.

The relatively-high, test-bed consumption of the simple turbine-jet is generally improved upon in flight, particularly at high altitude, say 36,000 ft. The reason is that, assuming constant turbine rpm speed conditions, the combustion temperature or the temperature of the gases at the turbine entry, together with the temperature rises across the blower, will remain approximately constant. Therefore, since the ambient temperature is lower at altitude, there will be a higher temperature ratio across the engine and a higher pressure ratio across the blower. These effects, however, may be offset somewhat by a drop in adiabatic efficiency and the "slip" factor of the blower.

With the simple turbine-jet a reasonable fuel economy can be obtained only at high speed and high altitude, for the propulsive efficiency, which is a function of jet velocity to aircraft velocity, improves with speed.

The mating of a particular turbine to its proper airframe is a most important consideration, and there is no doubt that the turbine-propelled aircraft must be "tailor-made" to suit its engine, or vice versa. In order to determine the correct size and type of turbine for a particular aircraft, it is necessary to know the following aircraft operating requirements: Speed, operational height, range, and whether for military or payload.

The turbine-propeller arrangement is more flexible in meeting the flight conditions of various types of aircraft of moderate speed (around 300 mph); and the propeller can be matched to the turbine and so designed that both will give the optimum efficiency in a particular aircraft.

(*Turn to page* 92, *please*)

AFTER Air Commodore Banks' presentation of his paper an interesting floor discussion was conducted by Sir Roy Fedden, chairman, with a number of leading authorities participating in it. Extracts from the comments of Dr. H. R. Ricardo, president of the British Institution of Mechanical Engineers, and Air Commodore Frank Whittle follow:

Dr. Ricardo—Rapid development of the gas turbine makes it as waste of time to attempt to develop piston engines of the conventional form of over 3000 hp; however, the cause of the piston engine is not entirely dead . . . success of the turbine will make piston engine people wake up and take stock.

The fuel consumption of a piston engine is a function of its expansion ratio, the power a function of the amount of oxygen that can be put into it. To stuff as much oxygen into the cylinder, compression is carried out in several stages, but expansion in only one and curtailed at that. By so doing we outraged the thermodynamic laws and had to pay the price in heavy fuel consumption and the need both for intercooling and for even higher octane fuels.

There is little case for developing special engines for civil transport. For civil use the highly developed military piston engine can be modified to the extent of increasing its expansion and lowering its first stage compression ratio, and by so doing get down to a fuel consumption of 0.40 lb per bhp-hr on 100-octane fuel. Considerable take-off power would be lost, but today several ways of accentuating temporarily the power of an engine are known.

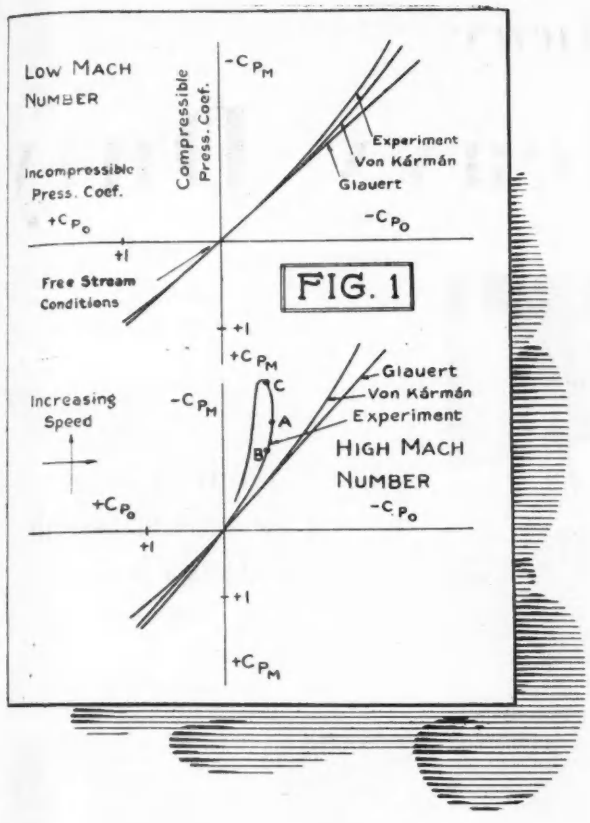
The efficiency of any heat engine depends, of course, on the range of temperature through which it can operate. The combustion, in reasonable time, of any hydrocarbon fuel in air gives rise to a temperature ranging from 2500 to 3000 C (absolute), depending on mixing strength, compression ratio, etc. That, then, is the starting point in either the piston engine or the turbine. Unfortunately, the turbine cannot digest a temperature much in excess of 1000 C (absolute). In order to bring the temperature down to that level it is necessary to supply a very large amount of dilution air, some four times that of the combustion air. If that dilution air were a free issue, it would not matter; but, unfortunately, it must all be handled and compressed by a blower, whose efficiency is substantially less than 100 per cent.

The piston engine, on the other hand, can cope with temperatures of the order of 2500 C or more, but, unfortunately, cannot usefully expand the gases down to below about 1500-1600 C. Surely the obvious line of development is to marry the two, using the piston engine to deal with the small volume, but high-temperature part of the heat cycle, and the turbine with the large-volume low temperature. Between the minimum temperature of discharge from the piston engine and the maximum that the turbine can at present accept there is still a certain gap; to bridge that gap some, but relatively only a little, dilution air will be required. But we can make a virtue of necessity, for the presence of excess air at once renders attractive the use both of the two-stroke cycle and of compression ignition. Of the two-stroke cycle because it can deal, with advantage, with a greater volume of air than its cylinder volume defines, hence a much smaller cylinder capacity will suffice; of compression ignition because the presence, in any case, of excess air in the cylinder removes the main handicap to Diesel operation, namely, that it is not possible to consume the whole of the air in the combustion chamber.

Air Commodore Whittle—The effect of the reduction of temperature with height in improving the efficiency of the gas turbine is not due only to the increase of compression ratio for a given speed. A very important factor is the increase of the positive-negative work ratio of the constant-pressure cycle for a given maximum combustion temperature. The positive-negative work ratio is so important that it imposes a limit on the raising of the compression ratio.

The effect of aircraft drag is even more important with the gas turbine than with the conventional aircraft engine of the piston type, and especially with the jet propulsion gas turbine, because the thrust horsepower developed with the latter is almost linear with speed; hence anything that is done to reduce drag automatically increases engine power. With the gasoline engine and propeller there is a tendency in the opposite direction at very high speeds owing to the falling off of propeller efficiency.

High fuel consumption is not an intrinsic characteristic of the gas turbine, if one keeps in mind the job of work for which the power plant is intended. Much lower fuel consumptions per thrust hp-hr than those obtained at present are possible at the price of increased complexity and weight, and whether or not it will pay to go for it depends again on the work the aircraft has to do. For some purposes a simple gas turbine of relatively high fuel consumption, measured in terms of thrust horsepower, could show such a saving in power plant weight that the fuel consumption in proportion to payload carried is actually lower than for the conventional power plant.



Compressibility Effects

at Speeds above 300 mph

By Dr. George L. Shue

Development Engineer, Aerodynamics, Consolidated Vultee Aircraft Corp.

IT is customary to treat air as an incompressible fluid in most work in aerodynamics. However, the density of the air varies with the pressure changes occurring in flow over an airfoil. The effects produced by this variation of density are commonly grouped under the heading, "compressibility."

Compressibility becomes increasingly important as the speed exceeds 300 mph. When speeds in excess of 400 mph are desired, compressibility becomes the chief design consideration. This is true because the local speed of the air passing some points of the airplane is greater than (or equal) to the speed of sound. The speed of sound is such an important item that it is convenient to give a name to the quotient of the air speed and the speed of sound. This quotient is called the Mach number. The critical Mach number is the Mach number at which the air reaches the speed of sound at some point on the airplane. The following effects of compressibility are observed:

1. The slope of the lift curve increases with increase of Mach number up to the critical speed and then decreases at super-critical Mach numbers.

2. The drag coefficient remains practically constant at sub-critical Mach numbers and then increases very rapidly as the critical Mach number is approached and exceeded.

3. The pitching moment coefficient may increase, decrease, or remain the same as the critical Mach number is reached.

4. When the critical Mach number is exceeded, shock zones are formed in the air stream. A shock zone is a narrow region at right angles to the air stream across which the air suffers an abrupt decrease in velocity. The loss in kinetic energy appears as heat and probably accounts for most of the increase in drag. The shock increases in intensity and moves rearward on the airfoil as the speed increases.

5. Both the stability and control of an airplane are affected by compressibility. Since it is rather common to use a thin section on the tail surface, the tail critical Mach number is higher than the wing critical Mach number. It is frequently observed that the stability at high speed increases to several times its low speed value and the control forces are so large that the pilot cannot control the airplane. With some pursuit planes the combination of stability and control has been such that the pilot cannot pull the airplane out of a high speed dive. Other cases have been ob-

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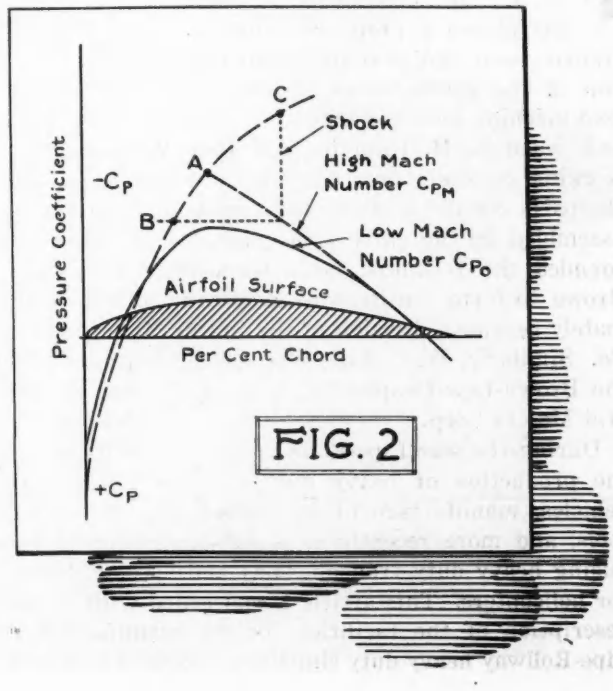
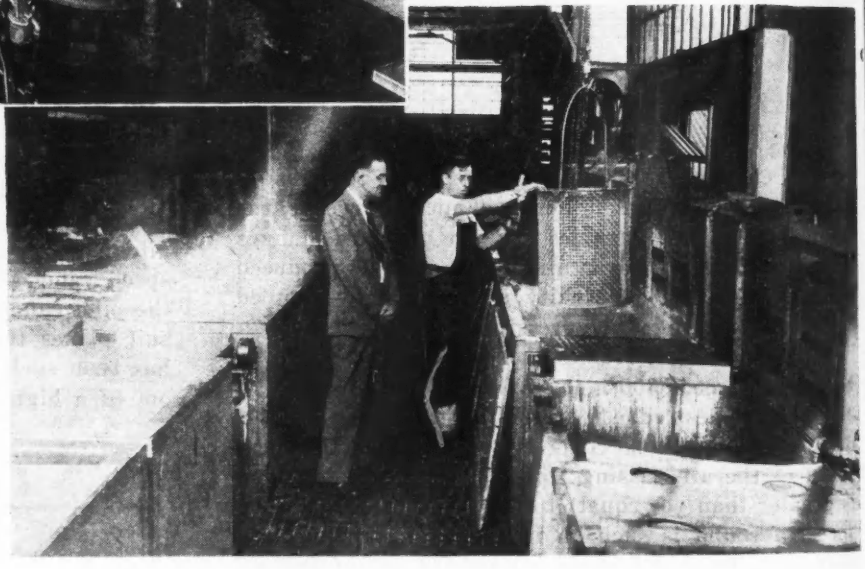


Highlights of Lipe-Rollway

Heavy Duty

This is the 105th in the series of monthly production features



(Above) Clutch cover plate assemblies are checked on the special inspection fixtures shown here. A record of controlling dimensions for each unit is logged for future reference.

(Right) Chemical cleaning and Parkerizing operations are performed in this department. Cleaning tanks are on the right, Parkerizing baths are on the left.

FOUNDED in 1875 in Syracuse, N. Y., the Lipe-Rollway Corp. has played a prominent role in transmission and gear developments and in the manufacture of specialized machine tools for industry. According to the record, when H. H. Franklin and John Wilkinson were working on their first aircooled automobile in 1898, the parts for the first car were made and the car was assembled in the early Lipe plant. C. E. Lipe, who founded the business, later teamed up with A. T. Brown to form the Brown-Lipe Gear Co., which ultimately became a division of the Spicer Manufacturing Co. Similarly, W. C. Lipe was one of the founders of the Brown-Lipe-Chapin Co., today a division of General Motors Corp.

During the war Lipe-Rollway has played its part in the production of heavy duty clutches for military vehicles, manufacture of its varied line of machine tools, and more recently as a sub-contractor in producing heavy duty transmissions and special clutches for helicopters. This article is concerned with a brief description of the facilities for the manufacture of Lipe-Rollway heavy duty clutches of single- and double-plate type which are essentially the same clutches so well known in the heavy duty motor vehicle field. However, the needs of military vehicles made it desirable to introduce several larger sizes and these will be available to the commercial vehicle industry after the war. In addition to the heavy duty truck clutch plant, the company operates a small plant located in another section of Syracuse for the manufacture of a special line of clutches for Army tanks.

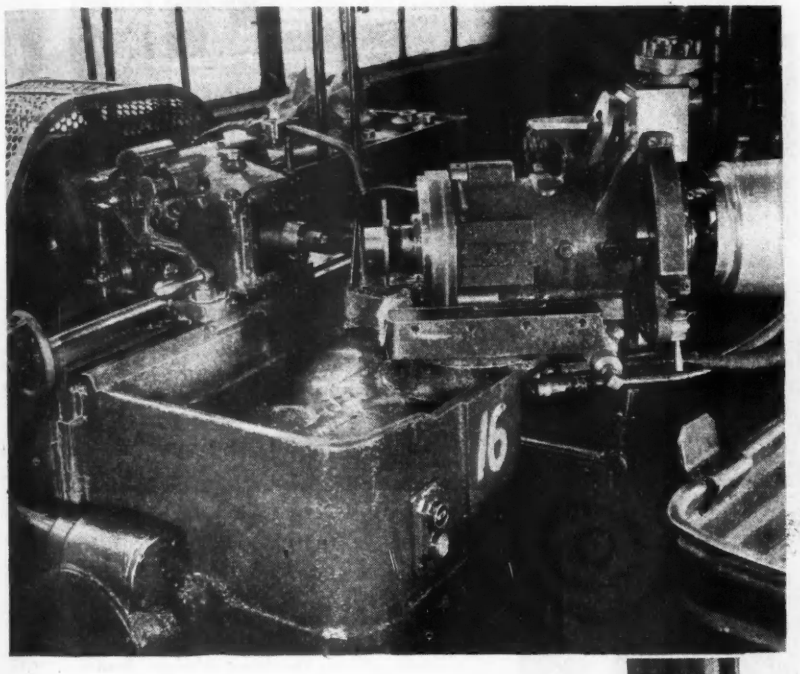
From a management standpoint it is of interest to find that the production methods developed by Lipe over a period of many years make it possible to build enough clutches for all normal demands in a relatively small plant. This is a natural by-product of specialization coupled with the evolution of simplified techniques. Perhaps of equal interest to production men is the fact that most of the machine tools found in this plant are adaptations of familiar makes of machines, in some instances completely rebuilt and fitted

Clutch Production

By Joseph Geschelin

with special attachments so as to produce, in effect, a specialized machine. As might be expected the facilities include many machines made by Lipe—Carbo-Lathes, gear pointing machines, and a battery of dynamic balancing machines designed and built here. In addition there are familiar makes such as—Cincinnati grinders, LaPointe horizontal broaching machines, Potter & Johnston turret lathes, Baker heavy duty drills, Blanchard surface grinders, Gardner grinders, Natco multiple spindle drills, Barnes Drill Co. drills, Brown & Sharpe milling machines, etc.

Clutch making facilities are distributed over three main floors of the building. The principal machine shop floor is arranged in three parallel lines for handling the three major elements of the clutch—the adjusting plate, the pressure plate, and the flywheel ring. Each of these parts is machined from a casting and the operations are completed by movement over each of the specialized lines. Below are found the routings for each of the major parts.



(Left) Unusual operation is the pointing of the ends of splines in the driven plate hub, using a Lipe gear tooth chamfering machine for the purpose.

(Below) Involute splines on the medium tank clutch spindle are finish-cut on Fellows gear shapers.

FLYWHEEL RING 14 In. STANDARD CLUTCH

Operation and Equipment

Clamp on fixture, grind face of 11⅝ in. diam.—Gardner Grinder.

Surface grind (3) rings at once—Blanchard surface grinder.

Jig drill (4) ½ in., (12) 13/32 in. and

(4) "O" holes. Also ream (4) ½ in. holes & countersink (4) 5/16 in. holes—Natco drill, Buffalo 2-spindle drill.

Chuck on 4 locating pins. Rough turn flange. Rough OD. Counterbore & bore, finish face flange. Finish OD. Chamfer 1/16 x 45 deg angle. Finish counterbore and bore. Finish pilot diam & break edges—Potter & Johnston turret lathe.

Mill 4 driving slots—Brown & Sharpe converted hydraulic mill.

Static balance—Barnes drill & Lipe balancing fixture.

Drill 2 holes for name plate—Buffalo drill.

Tap (4) ⅜ in. stud holes—Edlund drill.

Wash, inspect, clean and oil—Tank.

PRESSURE PLATE
Operation and Equipment

Chuck in bore, rough turn face hole on face plate, rough & finish turn OD—Gisholt, Rogers or Bullard vertical turret lathe.

Face 4 lugs, form fulcrum—Potter & Johnston turret lathe.

Mill 4 driving lugs—Brown & Sharpe converted hydraulic mill.

Rough grind face—Blanchard surface grinder.

Drill & tap 4 stud holes—Edlund special drill.

Finish grind face—Heald rotary grinder.

Static balance—Barnes drill and Lipe balancing fixture.

Inspect, clean and oil.

ADJUSTING PLATE
Operation and Equipment

Chuck on spring seat. Rough bore. Rough face fulcrum height. Rough 9.372 in. diam, rough OD, finish 9.372 in. diam & finish OD. Face flange, form recess. Finish fulcrum diam. Finish bore and break edges—Potter & Johnston turret lathe.

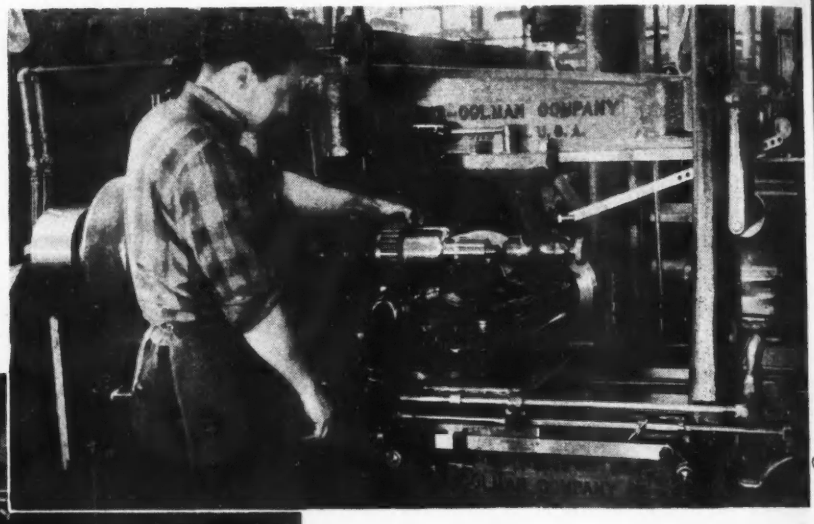
Mill 6 slots—Brown & Sharpe converted hydraulic mill.

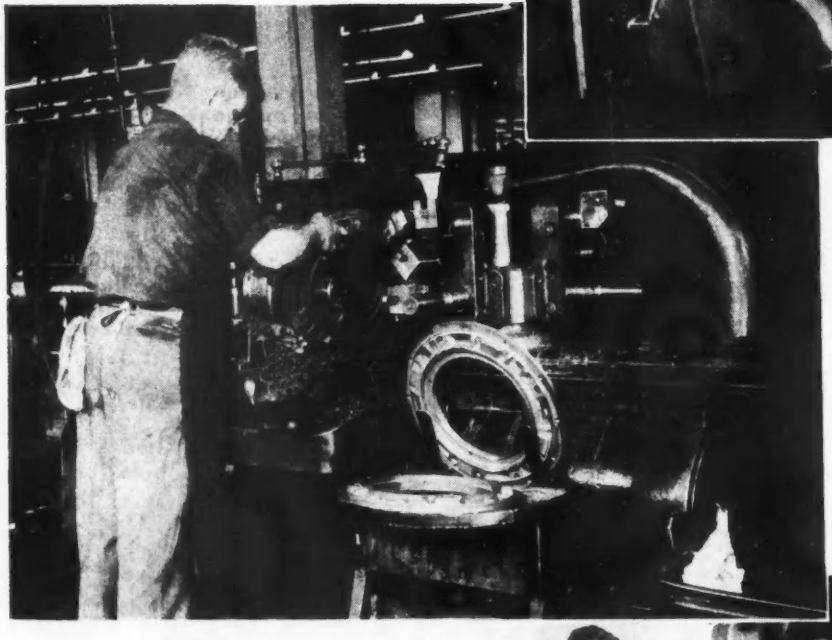
Spot face O.A.H.—Barnes drill.

Static balance—Barnes drill and Lipe balancing fixture.

Inspect, clean and oil.

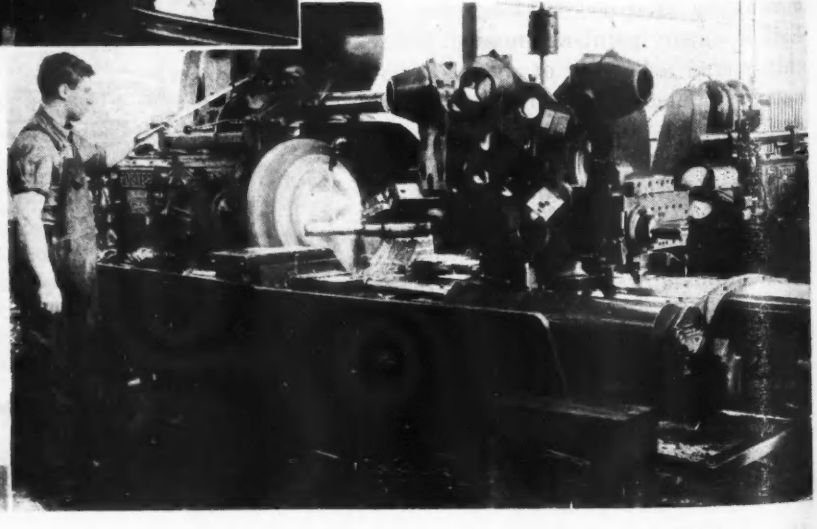
One of the parts of unusual interest to the user is the sleeve. This is made of a malleable iron casting which is hardened by the Aerocase process after machining and prior to final grinding operations. The machining is done in a series of steps on Baker drills, Potter & Johnston turret lathes, and several operations in Lipe Carbo-Lathes. Following these operations, the sleeve is given Aerocase treatment. The





(Above) Involute splines on the medium tank clutch spindle are cut on a Barber-Colman hobber.

(Below) 4F Foster Fastermatic is employed for the turning of cover plates for the medium tank clutches.



(Above) One of a battery of Potter & Johnston heavy duty turret lathes tooled for turning and boring of flywheel rings.

Lipe-built Carbo-lathes are prominent in the tooling of this plant. Here is a battery of these versatile machines rough and finish turning release sleeves.

OD then is ground on Brown & Sharpe or Cincinnati grinders, surface ground on a Heald rotary grinder. Final operation is Parco-Lubrizing to provide a long-wearing rust resistant surface. It is claimed that this specialized treatment results in extremely long service life.

On hub parts, the bore splines are produced in a LaPointe horizontal broaching machine. Unusual touch is the rounding of each spline tooth end on a special Lipe gear-pointing machine adapted for the purpose.

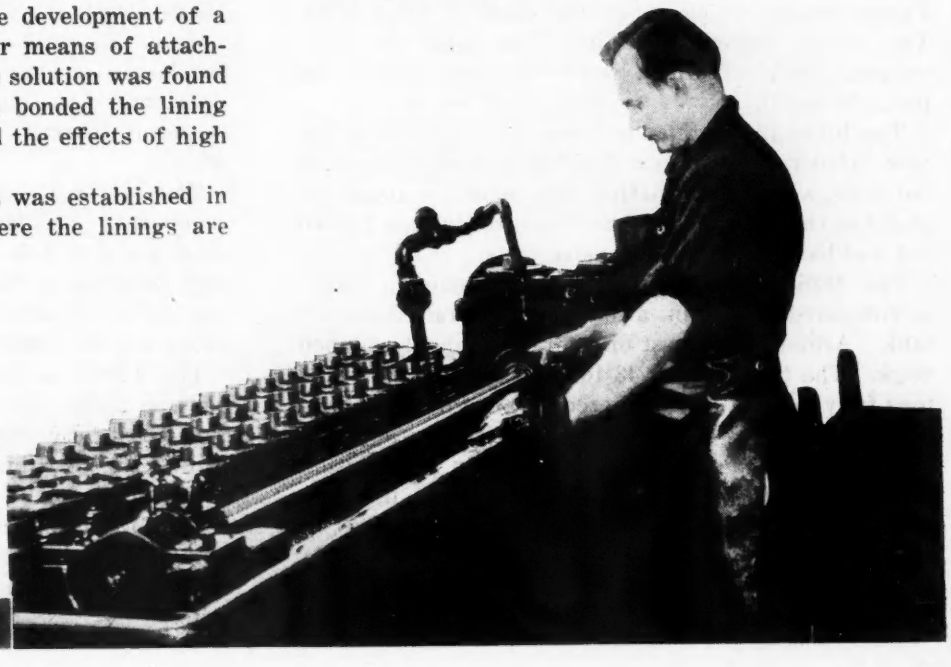
Machined parts are routed to an upper floor for final assembly operations. Here the job is sub-divided into sub-assemblies which are then moved to the assembly benches for final assembly into a clutch ready for installation.

It was found early in the military program that the requirements of military vehicles impose service far more severe than normal commercial operation. In particular, high rotating speeds and high pressures combined to produce loading which had a destructive effect upon the life of conventional friction linings. The situation demanded either the development of a new type of lining or some better means of attachment of the lining to the disk. The solution was found in a special plastic cement which bonded the lining to the disk and adequately resisted the effects of high rotative speeds.

A special cementing department was established in a corner of the ground floor. Here the linings are coated with the cement, applied on to the disk and tack-riveted to effect proper alinement. For bonding, the plate assemblies go to a special hydraulic press where the facings are held under pressure and heated for a given length of time. Heating is done electrically. An allied problem was the fact that the cement would not adhere properly to the steel surface. Various means were tried to improve adhesion, including shot blasting. However, the present procedure is to Parkerize the disks and this has been found to be the most satisfactory way.

The disk, with facings cemented on, go into the plate sub-assembly department where the facing is riveted securely. Then the disk is riveted to the hub in a special hydraulic press, designed and built by Lipe, the entire group of rivets being headed in a single operation. Following riveting, the disk is run-in for straightness and straightened if necessary. Then it goes to a special inspection machine where the operator checks the rivets, checks thickness, and passes upon straightness.

Final cover plate assembly starts with the benches. Skilled operators handle the assembly job at their individual stations. The assemblies then move down the line to the special Lipe dynamic balancing machines in which final balance is accomplished in a surprisingly brief interval of time—in the hands of skilled operators, of course.



LaPointe horizontal hydraulic broaching machine cuts the splines in the driven plate hubs.

OD of release sleeves is finish-ground on a Cincinnati Centerless grinder.

From the balancing stations the units move to the final test stands. They are mounted on dummy flywheels, actuated to simulate installation in a vehicle, and checked with special gages and instruments for conformity to specifications. In the small percentage of cases where the clutch does not pass inspection, it is taken off the line and transferred to a station for dis-assembly and reworking to meet specifications.

Of interest to customers and users is a small "rebuilding" department set up for rebuilding and repairing clutches returned from the field. This provides a service which assures factory quality of the product.

The foregoing is necessarily an over-simplification of a highly specialized operation. To do full justice to the production setup it would be necessary to describe in detail the conversion of standard machine tools to make them adaptable for use, in reality converting them to single-purpose machines not available on the market. Moreover, if such equipment were available it would doubtless cost a great deal more than do the converted machines. Suffice it to say, that skillful production management has made it possible to develop facilities of relatively low cost, implying lower amortization charges and consequently lower prime costs.

When the war is won and Lipe is back producing heavy duty clutches for its normal peacetime customers, they will offer a wider variety of sizes and will have a product reflecting the benefit of wartime improvements in design detail and manufacturing refinement.

Army Reveals Details of Two New Tanks

Lifting the veil of secrecy surrounding new Army developments for the first time, the Army Service Forces staged an on-the-record show at Fort Myer, Va., which brought out into the open its latest weapons, most of which were completed within the past six months.

The highlight of the show was the unveiling of the new "General Pershing" tank, now standardized as the M26, and the revelation that a newer improved model of this tank, the T26E4, has already been turned out and has undergone extensive tests.

The M26 is equipped with 4-in. armor in front, as compared with 3-in. armor on "General Sherman" tank. Armor on the rest of the tank is about one inch thick. The tank weighs 43 tons bare, and about 44½ tons fully loaded. It is powered by a Ford V-8, liquid-cooled, gasoline engine, which develops 500 hp. Equipped with a fluid drive mechanism and torsion bar suspension, its ride is smoother than in other tanks. The "General Pershing" carries a crew of five and has dual controls. Its armament consists of a 90 mm. gun, two 30 cal. and one 50 cal. machine guns, and it carries 70 rounds and 90 mm. ammunition.

Another innovation is the guide in the center of the bogie wheels. The guides on the bogie wheels of the "General Sherman" are on the outer edges of the wheels. In addition, the bogie wheels on the M26 are larger and the rubber is heavier. Featuring a 24-in. track as compared with a 16-in. track on the "General Sherman," the M26 can move faster on soft terrain.

The primary differences in the T26E4 are in the armament. The 90 mm. gun on this newer development has a muzzle velocity of 3750 fps, as compared with 3200 fps on the M26. The armor-piercing shells, carried by these tanks, and bearing a tungsten carbide core, can penetrate 14-in. armor at 300 yd.

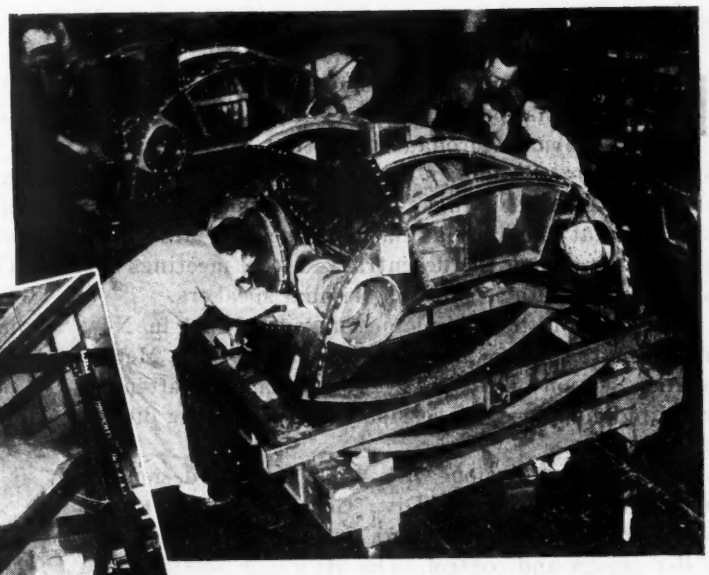
The T26E4 is equipped with twin 50 cal. machine guns on a freer swinging mount than the one 50 cal. gun carried by the M26. It is also equipped with two 30 cal. machine guns. The width of both tanks is 134 in.

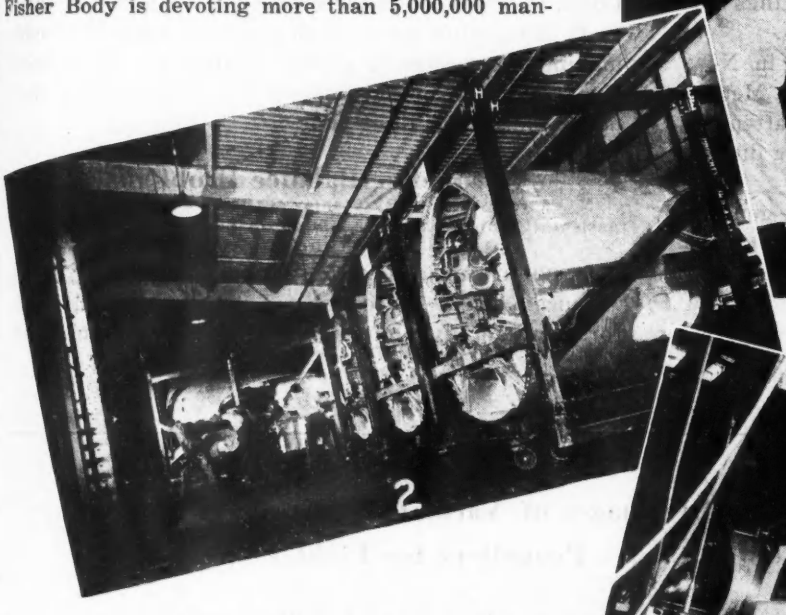
The M26 is in production and is in use in Europe. The T26E4 has not yet reached the production stage, but has been run over 4000 miles in its initial tests.

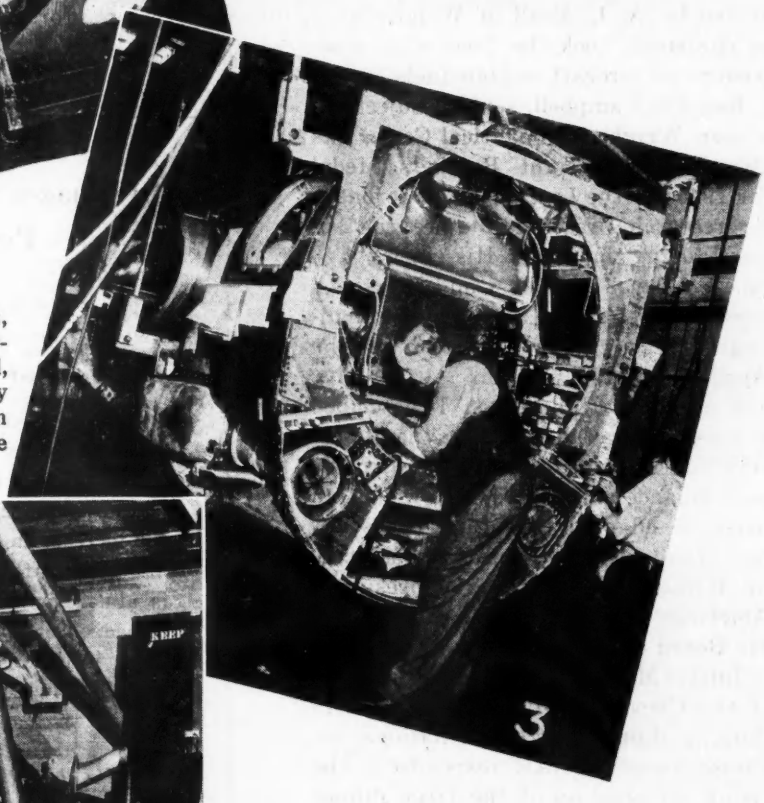
Fisher Builds

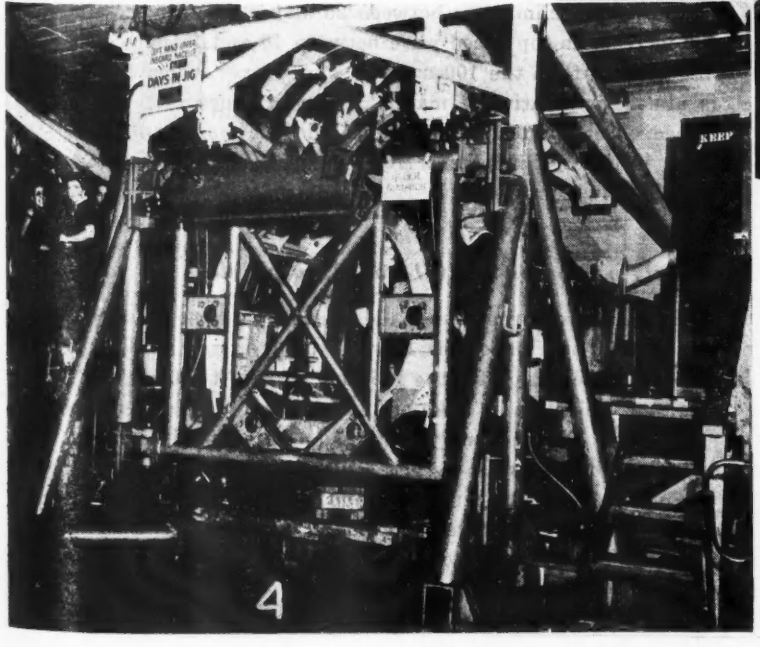
10,000 B-29 Engine Nacelles in Two Years

MORE than 10,000 B-29 engine nacelles, enough for 2500 Superfortress bombers and representing over 42,500,000 man-hours, were produced between April 20, 1943, and March 28 of this year at the East Side (No. 1) plant of the Fisher Body Division, General Motors. Each B-29 nacelle, without engine and auxiliary power plant equipment, weighs one ton and has approximately 3000 parts. The production pictures on this page show how Fisher has organized to assemble them in quantity. Fisher Body is devoting more than 5,000,000 man-hours per month to the B-29 production program, building parts and major assemblies for the Superfortress at 11 plants in Detroit, Pontiac, Cleveland, Lansing and Grand Rapids. Another Fisher Body plant at Memphis, Tenn., soon will begin production of an improved engine cowling assembly for the B-29.









1. *Lower sections on the assembly line.*

2. *Completed nacelles ready for shipment.*

3. *Fittings being installed as nacelle moves on overhead conveyor line in final stages before shipment to bomber assembly plant.*

4. *Assembling of B-29 engine nacelles begins in specially-designed jigs. Upper and lower sections are built separately and then joined together.*

By Philip Ruskin

First SAE Local A

IN conformity with wartime restrictions on conventions and national meetings, the customary three-day National Aeronautic Meeting of the Society of Automotive Engineers has been replaced by a series of local one-day meetings. The papers that were to be presented at the regular national meeting are being distributed among the decentralized local meetings for ultimate presentation by the original speakers.

The first of these local meetings was held in New York City, April 5, under the auspices of the Metropolitan Section of the SAE. More than 500 attended morning and afternoon sessions, and an evening dinner meeting.

The morning session, with W. J. Blanchard, general manager, Aeroproducts Div., General Motors Corp., as chairman, featured papers and discussions on propeller design and control. The afternoon session, conducted by A. L. Beall of Wright Aeronautical Corp., as chairman, took the form of a symposium on aircraft engine fuels.

Kenneth Campbell, senior project engineer, Wright Aeronautical Corp., was awarded the Wright Brothers Medal for 1944 for the best paper on aeronautic research presented before the society during that year. His paper, "Engine Cooling Fan Theory and Practice," presented before the National Aeronautical Meeting, was reviewed in the April 15, 1944, issue of AUTOMOTIVE *and* AVIATION INDUSTRIES. It described engine cooling fans as aerodynamic assets contributing greatly to airplane performance and explained how the fan must be adapted to engine needs for best results. The presentation was made by William Littlewood, vice-president, American Airlines, Inc., as chairman of the Board of Award.

James M. Crawford, chief engineer of the Chevrolet Div., General Motors Corp., and president of the national organization of the SAE, responded to the rising acclamation of the large dinner gathering with a few remarks relevant to the work of the SAE in aviation, the occasion of the evening and the future outlook.

The principal speaker was P. B. Taylor, vice-president, Wright Aeronautical Corp., who spoke on, "A Trip to the Pacific Theater." This was an illustrated lecture on living and operational conditions at many of the advanced bases of the U. S. Forces in the Pacific. Alfred Marchev, president, Republic Aviation Corp., was toastmaster.

Four of the five papers presented during the morning and afternoon business sessions are reviewed here in either abstract or summary form. The fifth paper, by John D. Waugh, Propeller Div., Curtiss-Wright Corp., is presented in pictorial form with the essential facts concerning each illustration in order to provide maximum coverage of a very lengthy and comprehensive treatment of the history of variable-pitch propeller control for light planes.

Propeller Balance Problems

By Stanley G. Best
Assistant Project Engineer, Hamilton Standard Propellers Div., United Aircraft Corp.

THERE are in general four types of propeller unbalance: mass force, mass moment, aerodynamic force and aerodynamic moment. Mass force unbalance

Advantages of Variable-Pitch over Fixed-Pitch Propellers for Light Planes

(From SAE paper by John D. Waugh)

Ten Tests of planes of 65 to 100 Hp.

Static thrust with variable-pitch propeller increased from 10 to 20 per cent over fixed-pitch type. Reduction in take-off run ranged between 30 and 45 per cent while the increase in the rate of climb was between 25 and 50 per cent. Values for increase in top speed were between 10 and 15 per cent.

For aircraft in the 100-mph class, and over, variable pitch is almost imperative if maximum performance is to be obtained. Certain tests have indicated that enough improvement is effected in planes from 75 hp, and up, to warrant variable-pitch provision.

Family of planes of 100- to 175-mph class

Variable pitch propellers made possible a 31 per cent reduction in take-off run for the 100-mph plane at sea level, and a 66 per cent reduction for the 175-mph craft. At 5000 ft. elevation, the reduction in take-off was 25 and 57 per cent, respectively. The increase in maximum rate of climb for the 100-mph aircraft was 36 per cent; for the 175-mph craft the increase was 38 per cent, from sea level. The increase in service ceiling with variable pitch was 24 per cent for the "100" and 11 per cent for the "175."

Aeronautical Meeting

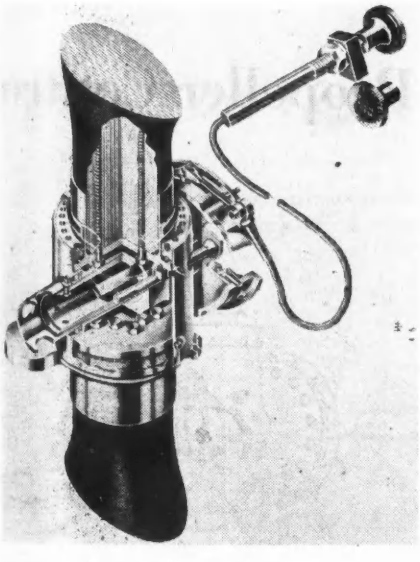
is defined as that condition in which the center of gravity of the propeller does not lie upon the axis of rotation. Mass moment unbalance is defined as that condition in which the minor principle axis of inertia is not parallel to the axis of rotation. Aerodynamic force unbalance is defined as that condition in which the torque forces on the individual blades are unequal, causing a resultant force to exist similar to that caused by mass force unbalance, perpendicular to the axis of rotation rotating with the propeller. Aerodynamic moment unbalance is defined as that condition in which the moments of the thrust forces on the individual blades about the center of rotation are unequal, giving

TENTATIVE SCHEDULE OF SAE LOCAL AERONAUTIC MEETINGS

New York, N. Y.	April 5
Dayton, Ohio	April 24
Buffalo, N. Y.	May 1
Detroit, Mich.	May 7
Kansas City, Mo.	June 7
St. Louis, Mo.	June 15

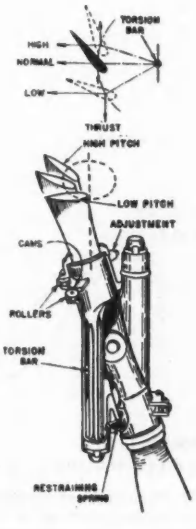
Propeller Control Devices for Light Airplanes

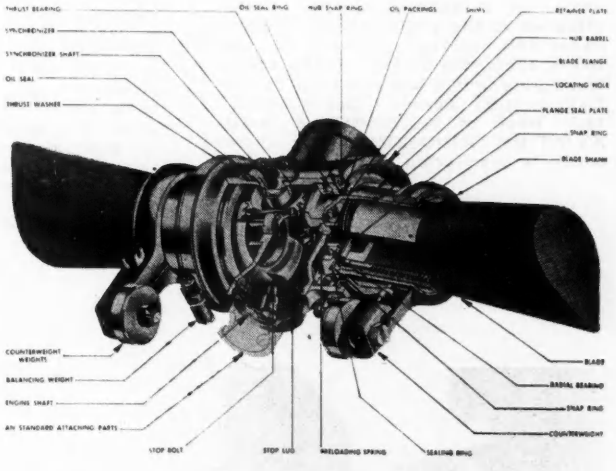
See other illustrations with their descriptions on the two following pages



ANNESLEY CONTROLLABLE PROPELLER

Change of pitch is accomplished manually by the actuation of a push-pull control in the cockpit, assisted by counterweights on the blades which neutralize the blade twisting moment. A vernier feature of the push-pull control enables the operator to select desired settings at any point between the extremes of movement which allow eight deg of blade travel, with a possible maximum of ten degrees. When desired, instantaneous change from high to low, or low to high, pitch can be attained by releasing the worm-gear mechanism in the control housing; this is effected by a slight downward pressure on the control knob.



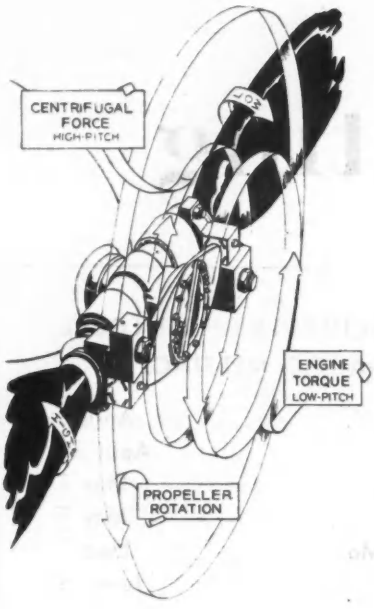


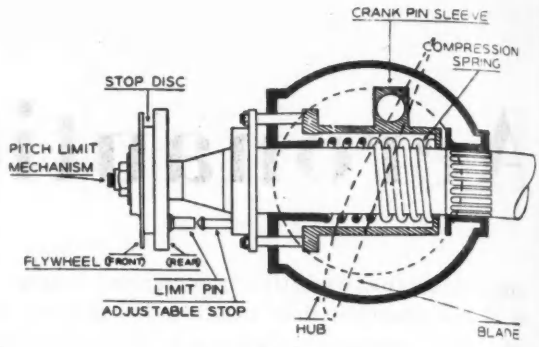
AEROMATIC AUTOMATIC PROPELLER

The combined actions of the natural forces on the blades and counterweights automatically accomplish the desired change in pitch for varying conditions of flight. The flange which retains the blade is designed to hold the blade at a fixed angle from the blade-pivot axis about which the blade is allowed to turn to change its pitch. The flange is so arranged in the hub that the blade describes an arc of a cone forward of the plane of rotation toward low pitch, or describes an arc of a cone rearward of the plane of rotation toward high pitch. High and low stops determine the range.

DE LAVAUD AUTOMATIC PROPELLER

Centrifugal force attempts to rotate the blades to a zero angle while aerodynamic thrust tends to decrease the angle. Blades are held in sockets which have an extension in the form of a torsion bar of cruciform section, set at an angle of 18 deg to the axis of the blade. The inner end of the torsion bar is fitted to an extension of the hub and is secured against rotation. The blade pivots in cone-fashion when rotated. The torsion bar permits rotation of about 10 degrees.





MILNER AUTOMATIC MULTI-POSITION PROPELLER

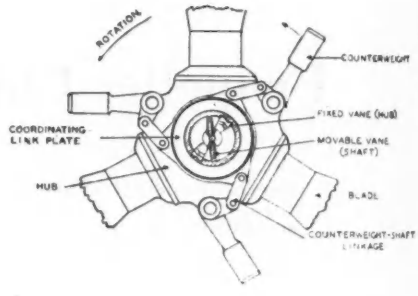
A compression spring resists the natural tendency of the blades to turn to low pitch. The propeller rotates, as an integral unit, on ball thrust bearings in a conventional fashion. Offset crank pins in the blade butts fit the arms of a sleeve which encloses a compression spring concentric with, and fitted over, the propeller-shaft spline sleeve. When the propeller is rotated at a certain, predetermined speed, the centrifugal twisting moment moves the blades to low pitch since the latter moment is greater than the spring moment at high pitch.

WICKWIRE-SPENCER AUTOMATIC PROPELLER

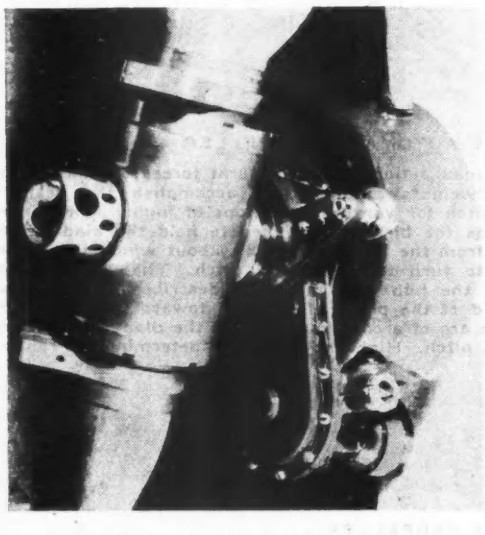
Acts as a governor to maintain constant engine speed for a given torque or power by utilization of forces provided in the engine-propeller combination. Engine torque reduces pitch and centrifugal force acting on blade counterweights increases pitch. The hub is mounted to rotate through a limited angle on a splined-coupling sleeve attached to the engine shaft. A ball-ended-arm assembly, fixed to the sleeve shaft, fits sockets in the counterweights which are attached to the blade-adapter sleeves. (See April 15, 1945, issue of AUTOMOTIVE AND AVIATION INDUSTRIES for more complete description of this device.)

GNOME-RHONE AUTOMATIC PROPELLER

Engine torque is balanced against the action of centrifugal force influencing the movement of counterweights mounted on the hub. The propeller shaft is geared directly to the blades which are mounted in a floating hub; the hub is shifted back and forth relative to the propeller shaft during pitch changes. High engine torque acts through the shaft drive-gear to turn the blades to low pitch, depressing the counterweights and shifting the hub. Centrifugal force tends to force counterweights to recover original position and to shift hub in a direction opposite to that induced by engine torque.

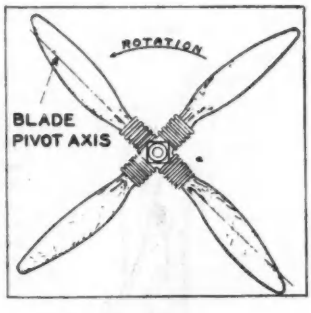


Propeller Control



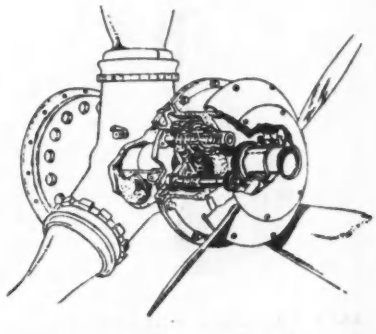
FREEDMAN-BURNHAM CONTROLLABLE PROPELLER

Mechanical (spring) forces and blade counterweights operate against the blade centrifugal twisting moment to normally force the blades to high pitch. Hydraulic pressure, controlled from the cockpit, is used to force the blades to low pitch.



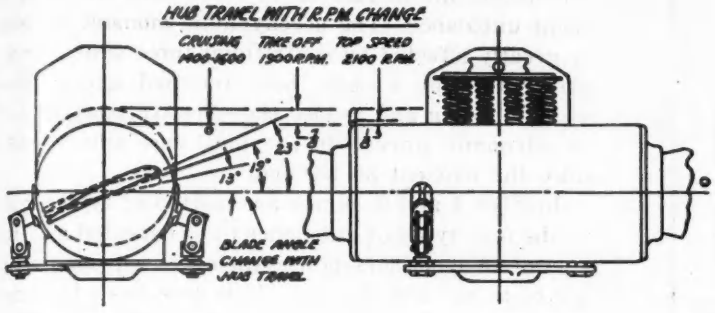
LEPARMENTIER AUTOMATIC PROPELLER

One of the earliest developments on record dating to 1921. The blades are staggered backward in the plane of rotation so that the blade area is behind the blade-pivot axis. Aerodynamic thrust causes the blades to cone forward in a pitch-decreasing sense while centrifugal force creates an opposing force tending to rotate the blades in a pitch-increasing sense.



RATIER AUTOMATIC PROPELLER

Action of aerodynamic torque on a servo-screw mounted on the front of the hub is utilized to effect a change in pitch. The servo-screw is fixed during operation but may be adjusted on the ground when the engine is stopped. At take-off, the setting of the servo-screw is such that it has a large angle of attack causing a drag or retarding effect. As a result, the servo-screw rotates relative to the propeller and at a slower speed. Interposed gearing transmits the retarding force to the pitch-changing mechanism.

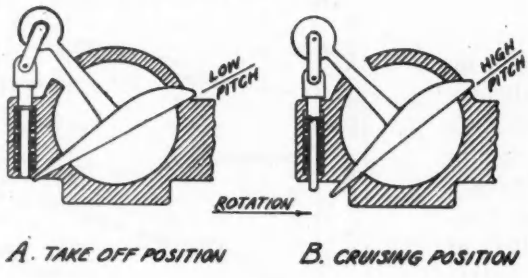


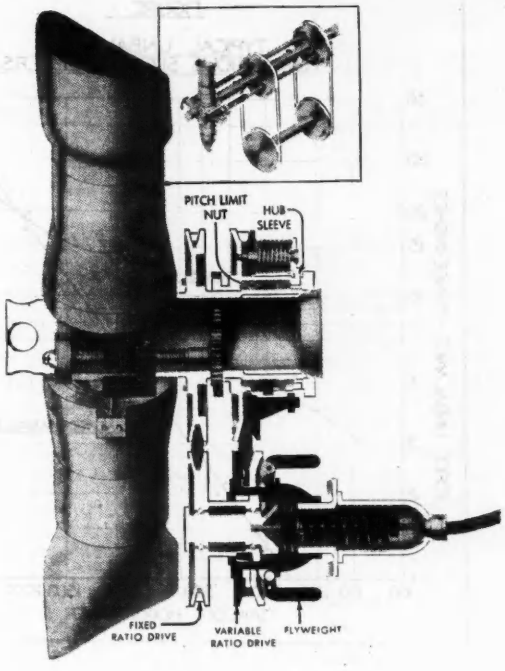
ECLIPSE AUTOMATIC PROPELLER

Propeller thrust is balanced against spring pressure. There are three units: A spring housing fixed to the propeller-shaft sleeve; a hub which can slide on the shaft sleeve; and the rotatable blades. Thrust of the blades causes the propeller to move forward against the pressure of a number of coil springs arranged in a circle concentric with the propeller shaft. These springs are retained by a plate fixed to the shaft sleeve. At the rear of the hub and fixed to the shaft sleeve, is a plate having links which are connected through the hub to the blade roots. As the hub moves forward, the links fixed to the rear plate cause the blades to rotate to a lower angle.

SCHWARZ AUTOMATIC TWO-POSITION PROPELLER

Spring tension, which has a tendency to hold the propeller blades in low pitch, is balanced against a counterweight on a lever arm. The counterweighted lever-arm is acted upon by the centrifugal force of the rotating propeller to cause the blades to move to high pitch.



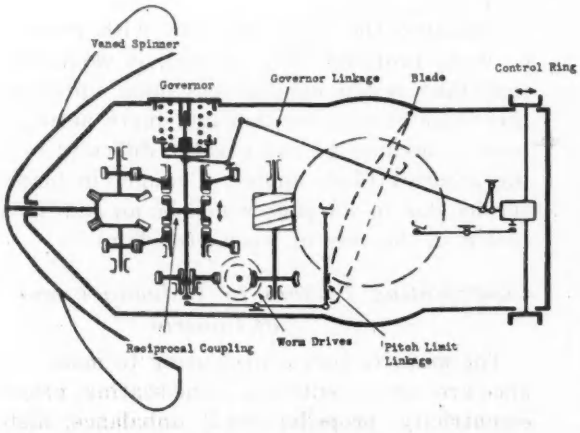


ISO-REV CONTROLLABLE PROPELLER

Constant engine speed and pitch change are provided automatically by the action of centrifugal force of propeller rotation on the flyweights of the propeller governor. Movement of the flyweights is controlled by spring loading, the amount of which can be adjusted while in flight from the cockpit by means of a push-pull or flexible connection. Governor speed is a function of engine speed through a fixed-ratio pulley. A variable-ratio drive transmits governor demands for pitch change through a sleeve arrangement which, in turn, is connected to the pitch-changing mechanism through gearing.

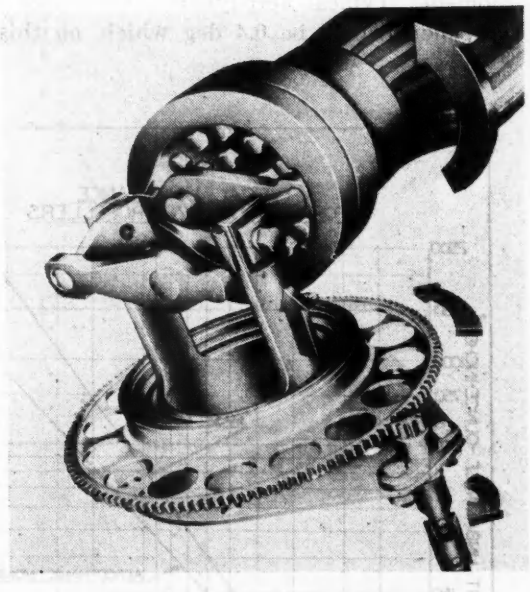
Devices for Light Airplanes

See other illustrations with their descriptions and report of the SAE Aeronautical Meeting on the two preceding pages.



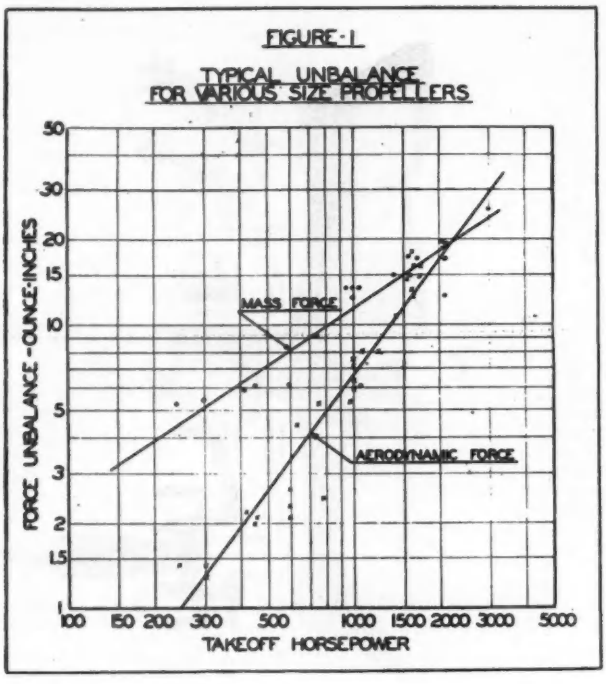
GERMAN ARGUS CONTROLLABLE PROPELLER

This propeller features constant speed and feathering. Control is effected by a push-pull linkage from the pilot to a control ring on the rear of the propeller hub. Power for changing the blade angle is derived from air resistance to a vaned spinner which is mounted on the front of the hub and is connected by a shaft to the internal reduction gearing.



BEECHCRAFT CONTROLLABLE PROPELLER

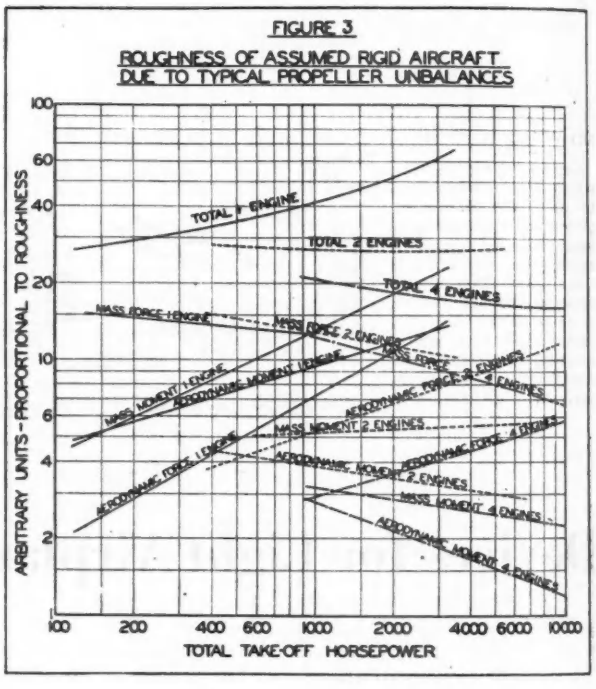
The control is purely mechanical in nature. Pitch changes are accomplished by suitable gearing which is motivated, at the discretion of the pilot, by a crank in the cockpit of the plane. Electric motor drive has been substituted for hand cranking in certain models of this control. A pitch indicator dial, located in the cockpit, provides a means of setting the pitch to a definite amount or of determining the pitch reading of a given setting.



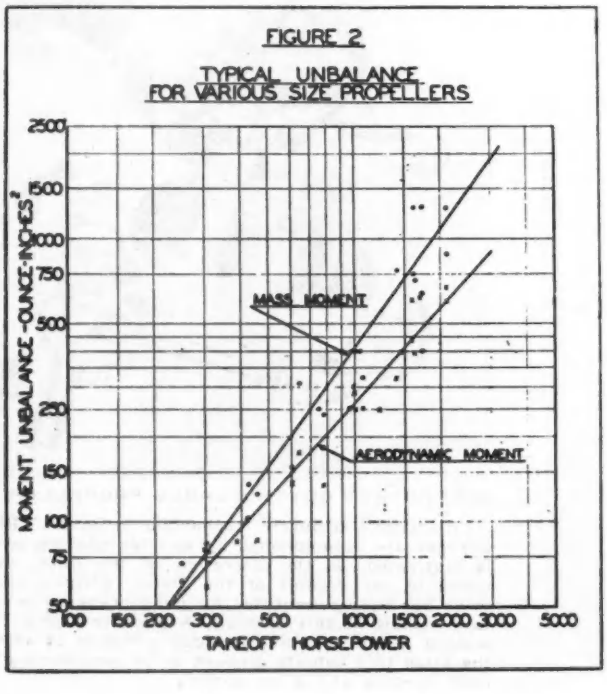
rise to a resultant moment similar to that caused by mass moment unbalance, about an axis perpendicular to the axis of rotation rotating with the propeller.

Hamilton Standard has accumulated sufficient data on dural propellers to estimate the amounts of each type of unbalance to be expected in typical cases. Considerable data have been accumulated on propellers of the 12-ft diam, 1600-hp class, which may be extrapolated within reasonable limits to propellers of all sizes. For a propeller in this class weighing 396 lbs with 1260 lb-ft² polar moment of inertia, typical mass unbalances would be 15 oz-in. force and 700 oz-in² moment. Typical aerodynamic unbalance on all size propellers would be 0.4 deg which, on this propeller, would amount to 12.3 oz-in. force and 450 oz-in² moment unbalance. The aerodynamic moment unbalance is greatly affected by centrifugal force which tends to straighten out a blade bent forward under aerodynamic loading and reduce the effective moment of the aerodynamic forces. In a typical case this would reduce the moment 30 per cent.

In Figs. 1 and 2, curves are plotted of typical values of the four types of unbalance to be expected as a function of take-off horsepower rating based upon a number of actual installations. It is seen that, in general, aerodynamic force unbalance is less than mass force unbalance for small propellers but becomes more important in larger propellers, being greater than the mass force unbalance above the 2250-hp class. Aerodynamic moment unbalance is less important than mass moment unbalance except in very small propellers.



Although the available data with respect to steel or wood propellers are limited, it would be expected that they would exhibit less mass unbalance due to their lighter construction and more aerodynamic unbalance because of the greater difficulty of maintaining accurate blade angles. Changes in blade angle in service due to warpage would be an additional complication in the case of wood propellers.



Contributing Factors to Unbalance and Methods of Control

The main factors contributing to mass force unbalance are cone eccentricity, cone seating, propeller shaft eccentricity, propeller shaft unbalance, distortion of the propeller under centrifugal loading, unbalance in individual parts which are in balance at one blade angle but change relative position with blade angle (including the blades themselves), non-symmetrical

(*Turn to page 50, please*)

Postwar Pistons

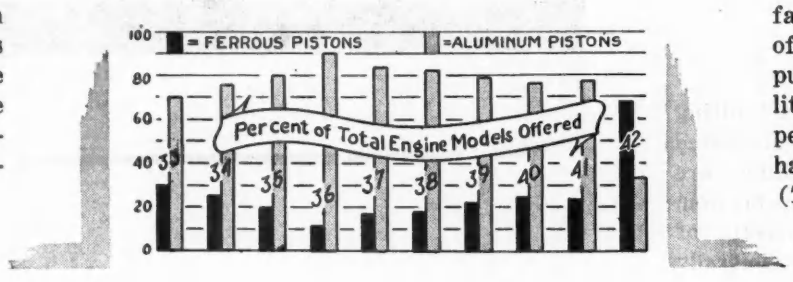
By Joseph Geschelin

WHAT can the engine designer expect in pistons for postwar use? The piston certainly is one of the most important elements of an internal combustion engine and it appears desirable to appraise the current state of the art so as to profit by such improvements as may be in the picture.

A brief survey among the leading producers of pistons leads to the conclusion that postwar progress is bound to be quite striking and will stem from several independent channels. The first of these is the experience gained from war production; the other, is the contribution to progress which will be made just as quickly as some of the principal producers are freed from their responsibility in the war program.

Cursory examination of the current situation leads to the conclusion that engine designers will not find really radical developments as by-products of the war. That is to say, in matters of design and materials, the situation is not changed materially. Yet it is unsafe to generalize broadly since it is apparent that some piston manufacturers have had an opportunity to broaden their field experience with improved designs which were about ready for introduction when the war stopped automotive production activity.

During the past four years the real task of any component manufacturer has been one of more and more output. There has been little opportunity to experiment. In fact, there has not been time to (*Turn to page* 38, *please*)



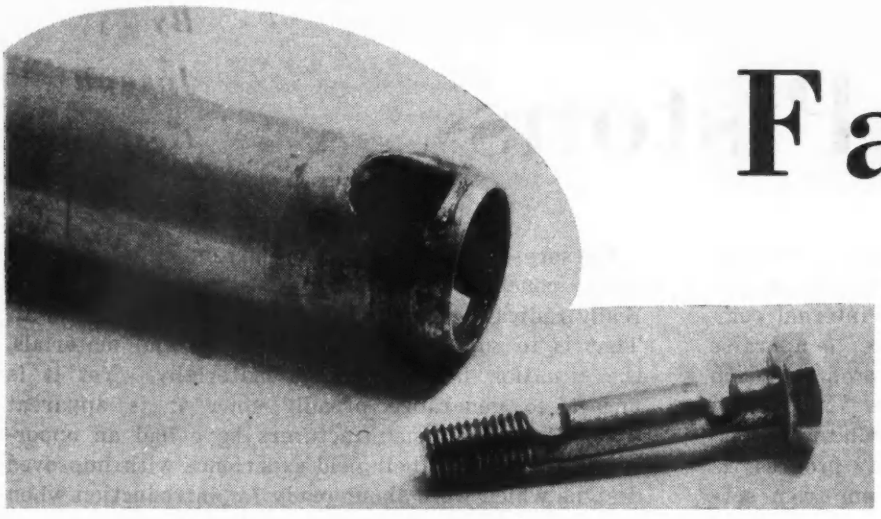
Passenger Car Engine Piston Material

Based on Number of Engine Models Offered *

MAKE	1933		1934		1935		1936		1937		1938		1939		1940		1941		1942†	
	Fe	Al	Fe	Al	Fe	Al	Fe	Al	Fe	Al	Fe	Al	Fe	Al	Fe	Al	Fe	Al	Fe	Al
Auburn		2		3		2		2		2										
Austin and Bantam		1		1		1		1				1		1		1		1		
Buick	3		3		4			2		2		2		2		2		2	1	1
Cadillac	3		3			3		4		3		2		2		2		1		1
Chevrolet	1		2		1		1		1		1		1		1		1		1	
Chrysler	1	3		4		5		3		2		3		2		2		2	1	1
Continental	2	1	1																	
Cord		1						1		1										
Crosley															1		1		1	
Cunningham	1		1																	
De Soto		1		1		1		1		1		1		1		1		1	1	
Dodge		2		1		1		1		1		1		1		1		1		1
Duesenberg		1		1		1		1		1										
du Pont		1																		
Essex and Terraplane		2		1		1		1		1										
Ford		2		1		1		1	2		2		2		2		1		2	
Franklin		2		2																
Graham		2		3		4		2		3		1		1		1				
Hudson		2		1		2		2		2		3		3		2		3		3
Hupmobile		3		3		2		2				2		2						
La Fayette	1			1		1		1												
La Salle				1		1		1		1		1		1		1				
Lincoln and Zephyr		2		1		1	1	1	1	1	1	1	1	1	1	1	1		1	
Marmon		1		1																
Mercury													1		1		1		1	
Nash		4		3		2		2		2		2		2		2		3	1	2
Oldsmobile	2		2		2			2		2		2		3		2		2	2	
Packard		3		3		4		4		4		4		4		3		3	2	1
Pierce-Arrow		3		2		2		2		2		2								
Plymouth		1		1		1		1		1		1		1		1		1	1	
Pontiac	1		1		2		2		2		2		2		2		2		2	
Reo		2		2		2		1												
Rockne	1																			
Studebaker	2	2		3		2		2		2		2		2		3		3	3	
Stutz		2		1		1														
Willys	2		1		1		1		1		1		1			1		1	1	
Willys-Knight		1																		
Total	20	47	14	41	10	41	5	41	7	34	7	31	8	29	8	26	7	24	21	10
Per Cent	29.8	70.2	25.5	74.5	19.6	80.4	10.9	89.1	17.1	82.9	18.4	81.6	21.6	78.4	23.5	76.5	22.5	77.5	67.8	32.2

* Data from the records of the Annual Statistical Issues of Automotive and Aviation Industries.

† WPB order effective restricting use of aluminum.



Fatigue

By Daniel M. Davis
Vultee Field Division,
Consolidated Vultee Aircraft Corp.

Fig. 1—Effect of vibration on part with oversize bolt hole.

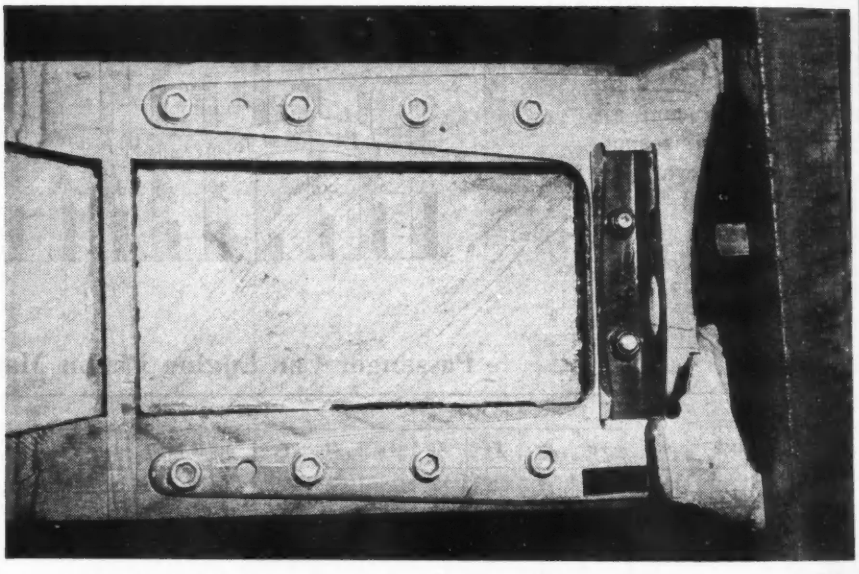


Fig. 2—Wing fitting failure after approximately 200 applications of applied load.

THE major factors limiting the life of parts subjected to repeated loading are stress concentration, deflection, and vibration. The effects of stress concentration generally may be evaluated in terms of three different parameters as follows:

1. The endurance limit is established for a "par" bar or part which does not have the stress concentration. A part with the stress concentration is then tested at the same load as the "par" part. The difference in life then becomes a measure of the stress concentration.

2. The tests are conducted as described in the preceding paragraph except the load is reduced to maintain the same life for the part with the stress concentration as was originally obtained with the "par" part. In this case, the ratio of the loads becomes the measure of the stress concentration.

3. The stress concentration is actually measured, either by means of photoelastic tests with a suitable plastic model, or by exploring the actual part under load with suitable strain gages to determine the actual stresses imposed.

The last mentioned means for determining the value of stress concentration yields very valuable information on the nature of the DESIGN. Quite often stress concentrations appear in unexpected places and for unexpected reasons, for instance, at the point of application of the load. These errors in design can be discovered and corrected with the expenditure of a great deal less time and money than by finding them the hard way by failure of parts in service.

However, this does not necessarily give a true evaluation of

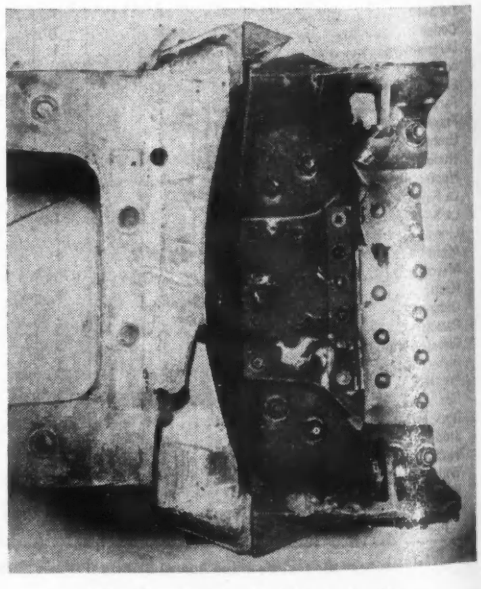


Fig. 3—Service failure of wing fitting.

From a paper prepared for presentation at the 13th Annual Meeting of the Institute of The Aeronautical Sciences, Jan. 29-31, 1945. Published with the permission of the Institute of The Aeronautical Sciences.

Failure of Aircraft Parts—

Their Cause and Cure

he life of the part in service as it does not ake into consideration the items causing educed life which are not a function of de- ign. These include internal stresses due to eat-treating or welding, or the notch effects f surface conditions because of machining. hese can be evaluated best by methods de- cribed in item 1 above. We can establish a ar" for the part by determining the amount f load and the number of applications of ad the part should withstand to insure a atisfactory life of the part as it is installed n the airplane. This would be included in he criteria to be established for the design f the particular type of part.

The effect of deflections can be shown in wo typical forms. Let us first consider a art like an antenna mast or pitot tube mast. et us assume—merely to simplify calcula- ion—that the elastic curve of deflection of he mast is similar to that of a cantilever eam uniformly loaded. The maximum stress n such a beam is

$$S = \frac{4\,E\,y\,d}{L^2},$$

here E is the modulus of elasticity; y, the istance from the neutral axis to the outer-

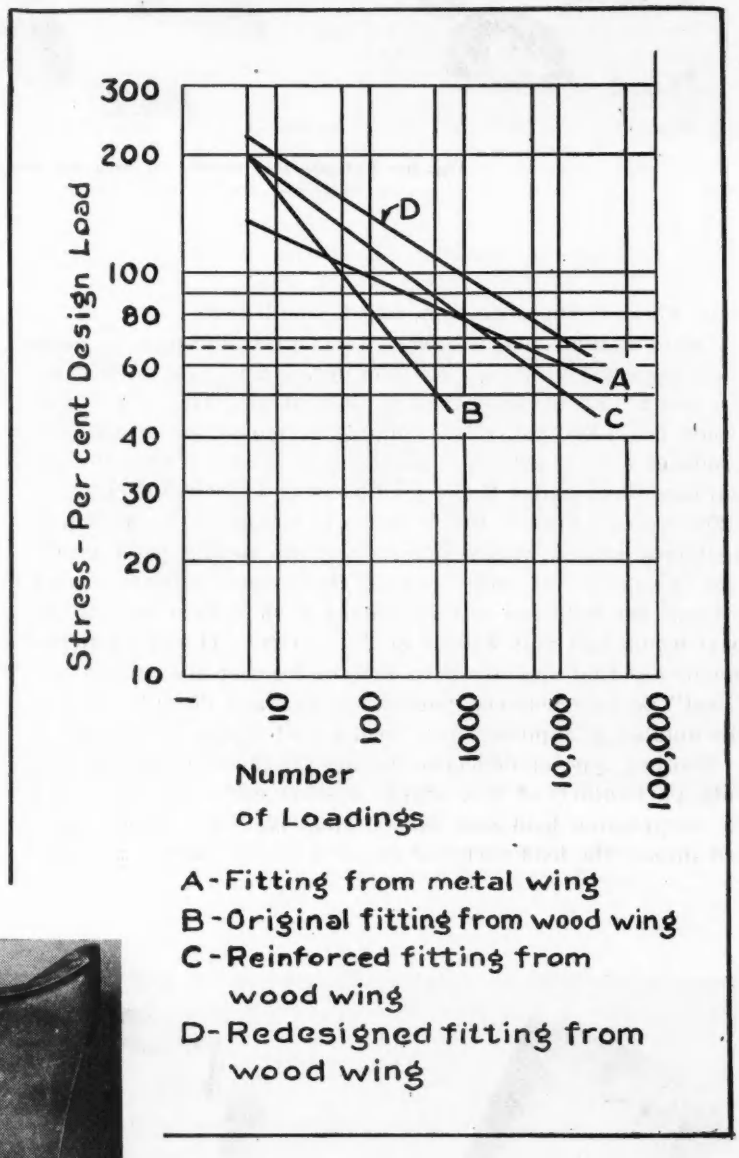


Fig. 5—(Above) S-N curves of wing fittings showing effect of design on slope of curve, and relative efficiency of designs.

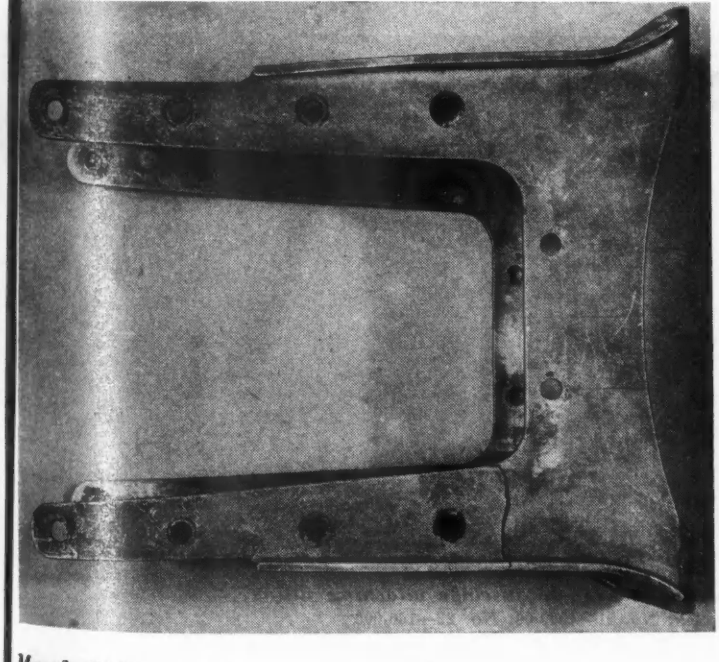


Fig. 4—(Left) Redesigned fitting for wood wing after 11,650 applications of applied load.

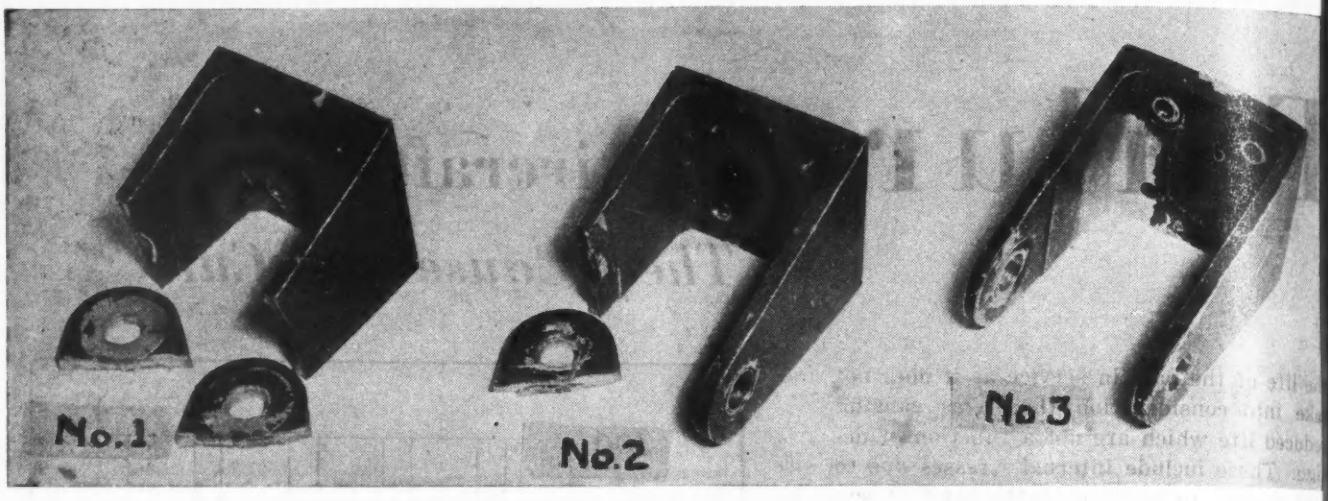


Fig. 6—Fatigue test results of original wing to fuselage attaching fitting.
Specimen No. 1—90,000 cycles; No. 2—38,300; No. 3—43,900

most fiber; d, the deflection, and L, the length.

Let us assume that a tube of 1½ in. OD, 30 in. long, picks up a resonant vibration of 1200 cycles a minute with a deflection of 0.5 in. to each side of neutral. The stress then would be 17,200 psi. The clamping action at the attachment produces a very serious stress concentration, so that the endurance limit under these conditions is 5,000,000 cycles. At 1200 cycles a minute this represents less than 70 hr of life. Just how long it would take to accumulate 70 hr of vibration is a matter of conjecture. If this type of vibration were present for only five minute during each hour of flight, the part would last only 840 hr of flying time. The thing to remember is that the effects of fatigue loading are cumulative. "Rest" periods between periods of loadings do not increase the number of applications of load a part is able to endure.

Another type of deflection occurs on sheet metal components, particularly at free edges. A sheet metal part subjected to compression load may buckle slightly. This usually does not impair the load carrying capacity of the part as a whole.

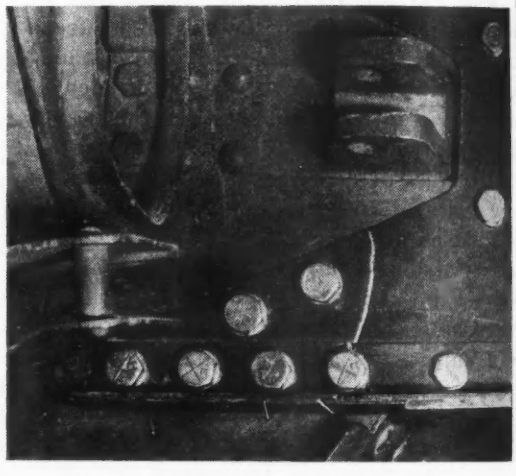


Fig. 8—Failure of vertical stabilizer attaching fitting, identical to service failure, after 2000 reversals of applied load.

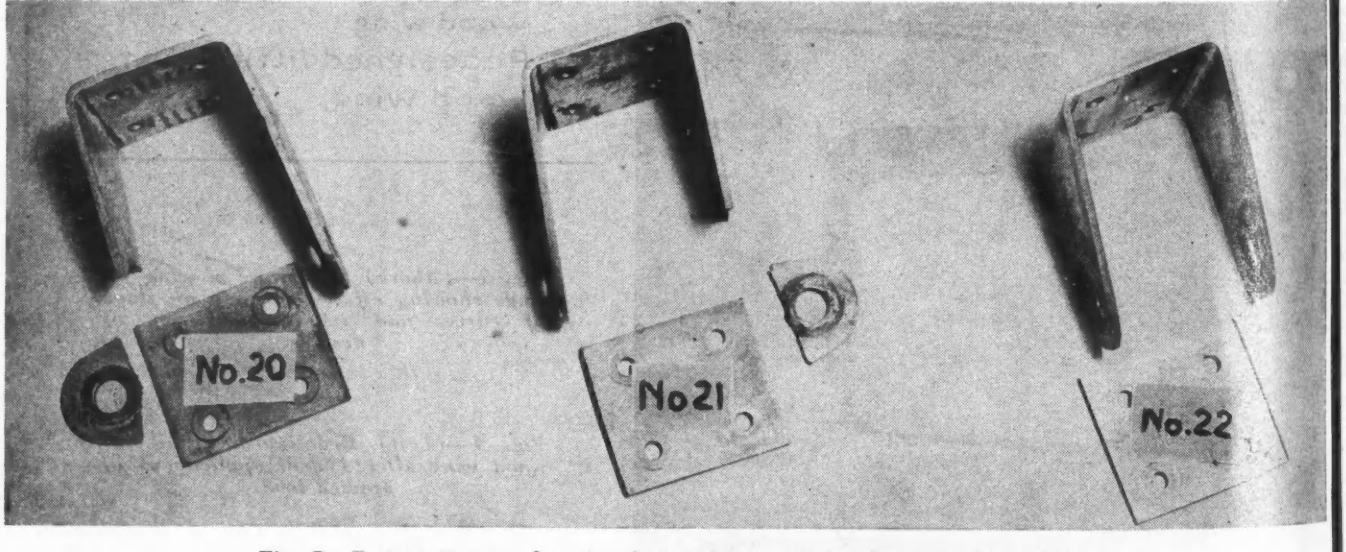
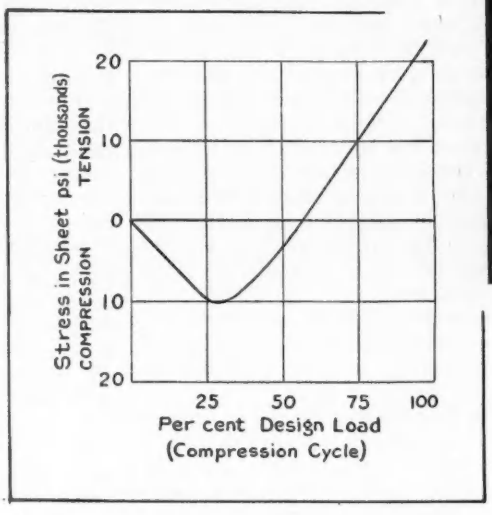


Fig. 7—Fatigue test results of redesigned wing to fuselage attaching fitting.
Specimen No. 20—120,000 cycles; No. 21—100,000; No. 22—160,000

However, at the buckle the stress starts out as compression, then as the height of the buckle increases the stress on the outside reverses itself to tension because of the local bending of the sheet. When this stress reversal occurs at an edge, which may have many tiny nicks and notches (the severest type of stress concentration), a very low endurance results for parts subjected to repeated loading.



When vibration is present, great accelerations may occur. The equation for the acceleration in "g's" in terms of deflection and frequency is

$g = .0000284dN^2$,

where d is the deflection to each side of neutral, and N the frequency in cycles per minute. Thus, when N is large, even small deflections can build up high loads. For example, suppose a part is subjected to a vibration of 2400 cycles per minute with a 1/16 in. deflection (single amplitude). The resulting acceleration is 10 *g*. Very few parts hold up very long under such conditions. Yet this condition exists in the power plant section of a number of airplanes, particularly in the attachment of accessory components. Witness the extreme frequency of failures of power-plant and nacelle components.

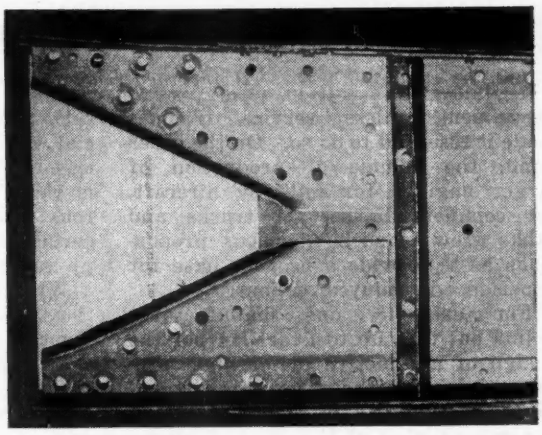


Fig. 10—(Above) Vertical stabilizer attaching fitting with flanges added. No failure occurred after 20,000 reversals of applied load.

Fig. 9—(Left) Stress reversal caused by buckling of sheet in compression.

Fig. 12—Fatigue test results of landing gear attaching fitting after adding sawcut to provide relief for stress concentration.
Specimen No. 5—Cracked after 176,600 complete reversals of load

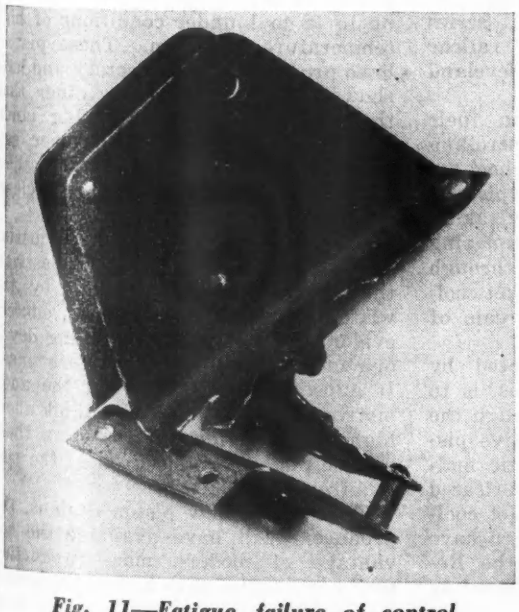


Fig. 11—Fatigue failure of control system pulley bracket.

An example of the effect of vibration is shown in Fig. 1. The part is a hand-crank extension for an engine starter. The only load on this part is due to its own weight, approximately 1½ lb. The bolt is ¼ in. in diameter, but through an error the hole in the part was drilled 1/16 in. oversize. The results shown are after about 100 hours of engine operation. While this is an extreme case of the effects of vibration, it serves well to illustrate the point.

Criteria for Fatigue Loading

At present there are no established standards as to stress range and number of load cycles a part should withstand. To require an infinite life under conditions of maximum load evidently would penalize the airplane from a weight standpoint. A limit must be set, and should be based on the expected frequency of loading and the expected life of the airplane. Some work of this nature has been done for automobile

(*Turn to page 67, please*)

Postwar Pistons

(*Continued from page* 33)

experiment unless service troubles made it essential to do so. On the other hand, the volume of production of larger engines for military aircraft, for commercial use, for trucks and tanks grew to such enormous proportions as to provide a broader base for experience in many directions.

For example, one manufacturer points out that up to Pearl Harbor the design of automotive pistons had progressed beyond those for aircraft engines, particularly in the technique of the cam-shaping of the skirt of aluminum pistons to provide uniformity of clearances under variations in operating temperatures. During the war, this improvement was extended to pistons for aircraft engines and the large tank engines.

Aluminum alloy has been widely used for pistons during the war. Pistons have been produced by the known methods—sand castings, die castings, permanent mold castings, and forging. In fact, we are told that the major portion of automotive sizes were made by the permanent mold process, following in this respect the practice before the war. The war encouraged greater use of forged pistons for the higher output aircraft engines to provide the substantially higher physical properties required for this service. With regard to forged pistons there are two schools of thought. So far as passenger car engines and other types of automotive engines are concerned, it is believed that the optimum physical properties are not essential. That implies that the permanent mold process will continue to predominate in this field of application.

In discussing the forged aluminum piston it is well to bear in mind that its field of usefulness lies in the area of certain types of heavy-duty, high-output, high-speed engines where optimum physical properties may be the governing factor. One important piston producer believes that forged pistons will be found essential for such heavy-duty engines, particularly in the future when super-octane fuels may become available. The combination of higher compression ratios and higher output will bring with it much higher temperatures than are now prevalent. Unquestionably whatever the opinion is of the field for forged pistons, the practice will become crystallized when designers really have an opportunity to go to work. So far as this discussion is concerned, suffice it to observe that there will be ample facilities for the production of pistons by any process that may be preferred.

One of the producers of large pistons comments on the interesting developments that have taken place in the use of high tensile cast iron, making possible the development of extremely light-weight pistons. It is anticipated that one of the fields in which such pistons doubtless will be of especial value is that of heavy-duty, low-speed engines. In this connection, it is well to recall that light-weight ferrous pistons were extensively used in certain makes of passenger car engines up to the time of the war.

What then are the specific contributions of the current era? There are several. In the first place, the accelerated demand for heavy-duty engines encouraged the development of improved machinery and improved production methods.

In this regard, techniques undoubtedly have had an impetus equivalent to the normal peacetime progress of perhaps ten years or more.

Too, it has been possible to better appraise the efficacy of various types of their protective coatings. Among the most widely used of these have been the electrodeposited coatings of cadmium, zinc, or tin; and the Parker-Lubrite type coatings. Sufficient data will become available after the war to provide the basis for the acceptance of preferred coatings.

The foregoing has dealt primarily with the range of engines commonly classified as automotive types. In the field of large heavy-duty engines, particularly Diesel engines, having bores from 6 in. and upward, there is considerable controversy and diverse opinion.

At the SAE National Diesel Fuels and Lubricants Meeting, Chicago, May 17, 1944, Flynn and Underwood, General Motors Research, presented a paper, entitled "Adequate Piston Cooling as a Means of Piston Temperature Control." This represented a review of many years of studies leading to the adoption of ferrous pistons, with suitable provision for cooling by directed oil pressure jets for the various General Motors two-cycle, Diesel engines—Detroit Diesel Div., 71 Series engines; Electro-Motive Div., railcar and "pan-cake" engines; and Cleveland Diesel Div., products.

The authors pointed out in their conclusions two methods of controlling piston temperatures. One school of thought employs aluminum pistons, gaining temperature control by taking the heat flow through the piston ring belt, the piston rings, and often through the cylinder liner—into the jacket coolant or directly into the air stream of an air-cooled engine.

The opposed practice, adopted by General Motors Diesel Divisions, is to control piston temperature through the use of a relatively non-conductive piston—of alloy cast iron, pearlitic malleable iron, cast steel, or fabricated steel—cooled with an oil jet. Jet cooling and coordinated piston design have been proved by the work of the Research Laboratories and are offered as a course worthy of wider investigation and adoption.

This subject was pursued further a the SAE Annual Meeting in Detroit January, 1945, with the presentation o a paper, "Piston Development Review," by Professor E. T. Vincent. The poin was made that the previous investiga tion was based upon conditions in whic no real comparison existed of the rela tive merits of ferrous and non-ferrou pistons, since it is claimed by Vincen that the design of aluminum piston thus analyzed was not suitable for oi cooling. On the other hand, the fer rous piston was designed specifically for oil cooling.

Prof. Vincent then suggested tha perhaps the real solution might b found not in piston design featurin "lots of heat conductivity metal" or i a relatively non-conducting metal, oi cooled and fitted with heat dams; bu in a combination of the two. Perhap by using ferrous metal at the heat re ceiving surface and aluminum or alumi num alloy at the heat dissipating sur face. Such pistons, he pointed ou have been used with some success i several high output aircraft engines.

Vincent concluded with the recom mendation that the SAE organize Research Group to investigate the va rious phases of this problem. He ad mitted that such bi-metal pistons wer employed on many occasions in the pas with but little success but submitte that this past history should not daun an aggressive research committee.

Commenting on Prof. Vincent's sug gestion, one of the larger producers o pistons expressed it as his opinion tha postwar engines using 100-octane gaso line will find it not only desirable, bu necessary to use aluminum pistons fo at least one major reason—their highe thermal conductivity.

One of the piston producing compa nies advises that it has supplied fo some time the equivalent of a patente low-expansion aluminum alloy for pi tons for four-stroke cycle Diesel en gines. Compression ratios have bee up to 18 to 1 under conditions of hig temperature operation. These piston have proved to be satisfactory and hav shown no signs of service other tha the usual sooting of the ring land ring grooves, and skirt. However, sa isfactory performances under the conditions is sensitive to proper clea ances, finishes and reliefs.

Reverting to the earlier discussio of what designers may expect postwa the investigation undertaken by th writer indicates that piston produce evidently have some outstanding deve opments under their collective bonne It appears clear that when the aut motive industry is ready to think abo high output engines for a new era, the will be piston designs to meet the ne requirements.

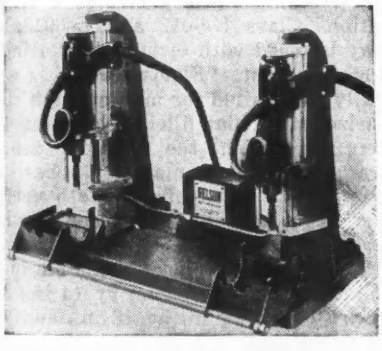
Given these new piston designs, th producers will have available the a vantage of modern mass productio methods, coupled with hitherto unkno levels of quality, at the lowest cos known to the art.

New Production Equipment

NELSON SPECIALTY WELDING EQUIPMENT CORP., San Leandro, Calif., has brought out an automatic stud welding unit to meet mass production requirements. Using this unit, two or more studs may be welded in one operation.

Each of the welding guns is mounted on a pneumatic air cylinder. Each cylinder is fixed to a movable arbor which can be adjusted to any spacing necessary for the work. The work is held in a mandrel, chuck, or special locating device—the setup being determined by the particular production problem at hand. The welding current is obtained from a conventional 400-amp generator, and is regulated by a timing control unit which automatically controls the length of arc flow, producing controlled and consistent welds.

The Nelson multiple stud welder production unit is operated with a single



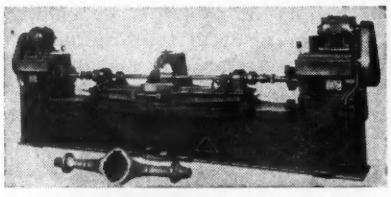
Nelson production welding unit

control switch. The work is inserted, stud is fitted into the chuck of each stud welding gun, and the control switch pressed. The first gun then descends making a weld. Upon completion of this weld the next gun descends and welds. The guns then ascend automatically and the work is removed. Each production unit is manufactured only on order to permit the unit to be made to fit the particular problem.

A SPECIAL machine for boring axle housings from two directions has been built by LeMaire Tool & Mfg. Co., Dearborn, Mich., utilizing the company's standard hydraulic units as the actuating mediums.

Two No. 5000 units are positioned opposite each other on a long fabricated base with an index type work-holding fixture in the middle between them.

The two boring bars are guided by bearings at each end of the axle and by



Le Maire machine for boring axle housings

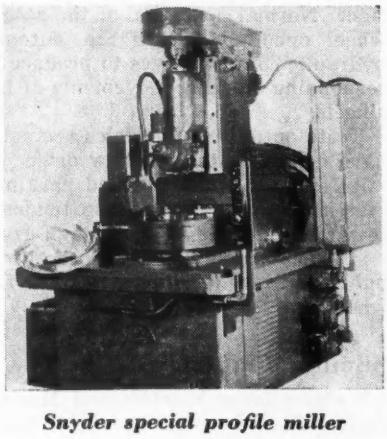
pilot bushings within the housing. The machine rough bores eight holes within housing and at the same time faces ends. In the second operation the roughing bars are replaced by finishing bars to obtain the following finished diameters: two 2.685-in. holes, two 2.654-in. holes, two 2.623-in. holes, and two 2.592-in. holes, all within .002 in. tolerance. Magic chucks facilitate the releasing of the bars from the units and allow the fixture to index when the changes are made. This arrangement made possible a shorter machine design to achieve economy in space.

SNYDER TOOL & ENGINEERING COMPANY, Detroit, Mich., has designed and built three special profile millers for three consecutive operations on an aircraft diffuser part with the objectives of expediting production on these parts and reducing hand finishing operations to a minimum.

In the first operation a vertical two-spindle end-milling machine is used to mill a 1/32 in. radius on each end of the nine diffuser vanes.

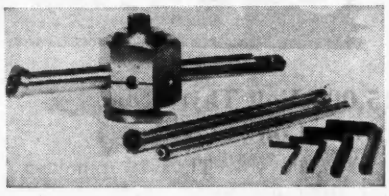
In the second operation (which is shown here) a vertical single-spindle miller is used to mill the outside contour of the vanes with side milling cutters set at an angle to the vertical spindle housing center line.

In the third operation a single-spindle vertical end miller is used to mill the inside contour of the vanes.



Snyder special profile miller

SHEARCUT TOOL CO., Bellingham, Wash., is making a new type boring and cutting tool holder for use with Shearcutter boring and turning tools. This tool holder is made in five sizes to



Shearcut boring and cutting tool holder

accommodate lathes and screw machines from 10-in. swing to 36-in. swing. Each tool holder is furnished with three boring bars, one of which is arranged for turning in the smaller sizes. In the larger sizes, two bars are arranged for turning as well as for boring.

BY use of the newly developed Coaxial Equalizer, the Induction Heating Corp. is able to couple two of its standard Model 1070 Thermonic induction generators so that the full output of both can be obtained from a single set of terminals.

Since each of the Model 1070 Generators has an output of 1070 btu per minute, 40 kw of power is available for use in any desired application with a single control station operating the tandem generator set-up.

The installation of the Coaxial Equalizer (made up of concentric tubular

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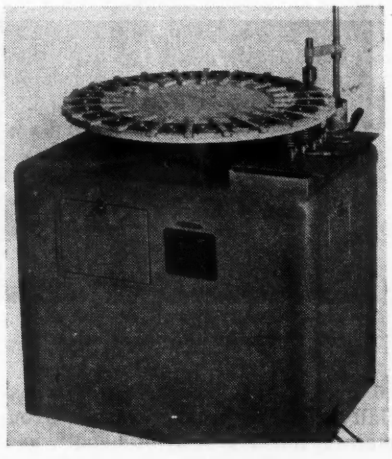


Illustrated is a 24-station circular indexing carrier made by "S" Corrugated Quenched Cap Co., Garfield, N. J., mounted on one of the company's 18-kw. electronic high-frequency generators to braze metal assemblies. A complete assembly is ejected from the carrier each 12 seconds. The operator's activities are limited to loading the stations as they come around empty. Heat is applied by a set of three water-cooled induction coils located under three of the work positions. The coils are followed by the vertically-operating ejecting mechanism. Carrier drive is by a small motor.

New Products

15,000 Volt Thyratron Power Control Tube

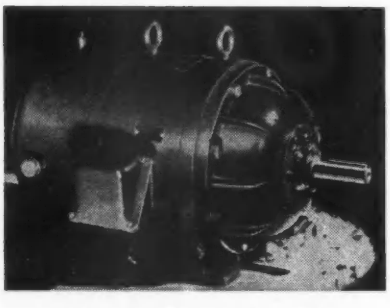
A 15,000 volt Thyratron power control tube providing split-cycle control of high power radio frequency heating units and radio transmitters, has been announced by the Westinghouse Lamp Division, Bloomfield, N. J.

The Thyratron WL-678 makes possible smooth and instantaneous power control from 0 to 100 per cent load; simplified automatic load control; high speed automatic overload protection; low space and weight requirements and low control power requirements. The new grid-controlled mercury vapor rectifier tube is designed to combine the high voltage characteristics of a Kenotron, control qualities of a Thyratron and efficiency of a Phanotron.

Explosion-Proof Motor

A new Class I, Group C, explosion-proof motor, for atmospheres containing ethyl-ether and similar vapors, is being offered by the General Electric Company.

Available in frame sizes 204-326, and in Types K (normal torque) and KG (high-starting-torque), the motor is rated ¼ hp at 600 rpm to 20 hp at 3600 rpm, 110, 208, 220/440, 550 volts, 60, 50, 25 cycles. The construction is essentially the same as the Class I, Group D motors, but a special flamepath is used at the shaft openings to cool the flame of internal explosions. Thermostats operate in conjunction with a magnetic controller to disconnect the motor at a predetermined temperature, but do not supplant regular overload relays.



G-E explosion-proof motor

Printer-Developer for Black and White Prints

Designed to provide printing and developing facilities for those who require black and white prints in medium quantities, a BW printing and developing machine, known as the Model 41, has just been brought out by the Charles Bruning Company, Chicago, Ill.

The Model 41 printer has a printing speed range up to 6 fpm, depending on the transparency of the original, printing either roll stock or cut sheets, with a printing width of 46 in. The light source is a 2,000-watt glass mercury vapor lamp within a 6-in. diameter cylinder. A new method of cooling pulls air into and through the cylinder and contact bands, resulting in minimum machine temperature.

Bruning Model 41 printer-developer

Steering Device to Ease Road Shock

Bendix Aviation Corp. has released information on a new hydraulic power steering device which is now in use on armored cars and tank-recovery trucks, and which will find postwar use in overcoming such motoring problems as "road shock," "driver fatigue" and even the parking problem.

The new device relieves the driver of steering effort in much the same manner that vacuum power brakes relieve him of physical effort in brake operation. Normal operation of the steering wheel opens or closes the automatic hydraulic control valves to produce corresponding steering movements of front wheels.

Tests on military vehicles are said to have demonstrated the new device permits easy maneuvering and parking in restricted space, eliminates tendencies toward "wandering" over rough ground and has virtually abolished "wheel fight" and even "shimmying" of front wheels.

Slimline Fluorescent Lamps

Westinghouse Electric and Manufacturing Co. has placed on the market four new fluorescent lamps, named Slimline because they are longer and more slender than the present standard line of fluorescent lamps. They are of the high efficiency hot cathode type, as are the other fluorescent lamps, but are designed for "instant start" operation without starters. They can be operated at various levels of wattage output and brightness. The compact cathode and base structure of the lamps results in the maximum continuity in the line of light formed when the lamps are mounted end to end.

The four sizes which have been announced are: the 42-in. T6, the 64-in. T6 (¾-in. bulb diameter), the 72-in. T8 and the 96-in. T8 (1-in. bulb diameter).

All-Position Welding Electrode Announced

A new shielded arc electrode for general purpose welding of mild steel which offers a number of advantages is announced by The Lincoln Electric Company, Cleveland, Ohio.

The new electrode, designated as "Fleetweld 47," offers such advantages as extremely low spatter loss, easy slag removal (most welds are said to be practically self-cleaning), excellent restriking characteristics, and other improved features.

"Fleetweld 47" conforms to American Welding Society electrode specifications Class E-6012 and E-6013, and may be used with either alternating or direct current. "Fleetweld 47" is especially well suited for making high speed horizontal or flat fillet welds over 4 in. long in which the coating can be dragged on both plates. It has also been used extensively for both vertical and overhead fillets, especially where large single pass fillets are desired.

This new electrode is available in the following sizes: 5/32 in. by 14 in., 3/16 in. by 14 in., ¼ in. by 18 in., and 5/16 in. by 18 in.

Electrically Powered Crush Dressing Device

An electrically powered crush dressing device for forming the wheel on the

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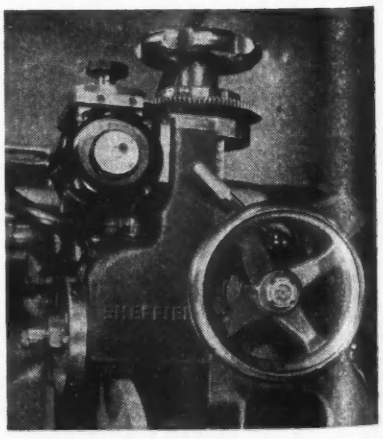

Sheffield Model A electrically powered crush dressing device

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New Products for Aircraft

Engine Performance Indicator for Planes

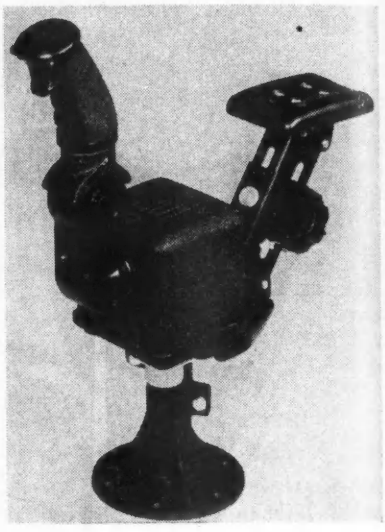
Consolidated Vultee Aircraft Corp., San Diego, Cal., has developed an instrument known as an "engine performance indicator." It is installed adjacent to the carburetor of an airplane engine, and its function is to measure the distance (right or left) to which the engine is displaced when the propeller is rotating.

If the engine is functioning normally, the instrument actuates a gage in the pilot's compartment, and this gage shows how much horsepower the engine is putting out. Then, if the engine begins to operate improperly the gage needle oscillates accordingly and a warning light glows on the pilot's instrument panel—giving the pilot time to cut the engine and feather the propeller.

New Control for Planes

An electronic control stick for use on four-engined bombers has been originated by the Minneapolis-Honeywell Regulator Co., Minneapolis, Minn. Called a formation stick, the control is a pistol-gripped lever about 10 in. long, mounted with an arm rest beside the pilot. It is free to move in all directions in exactly the same manner as the

(*Turn to page 76, please*)

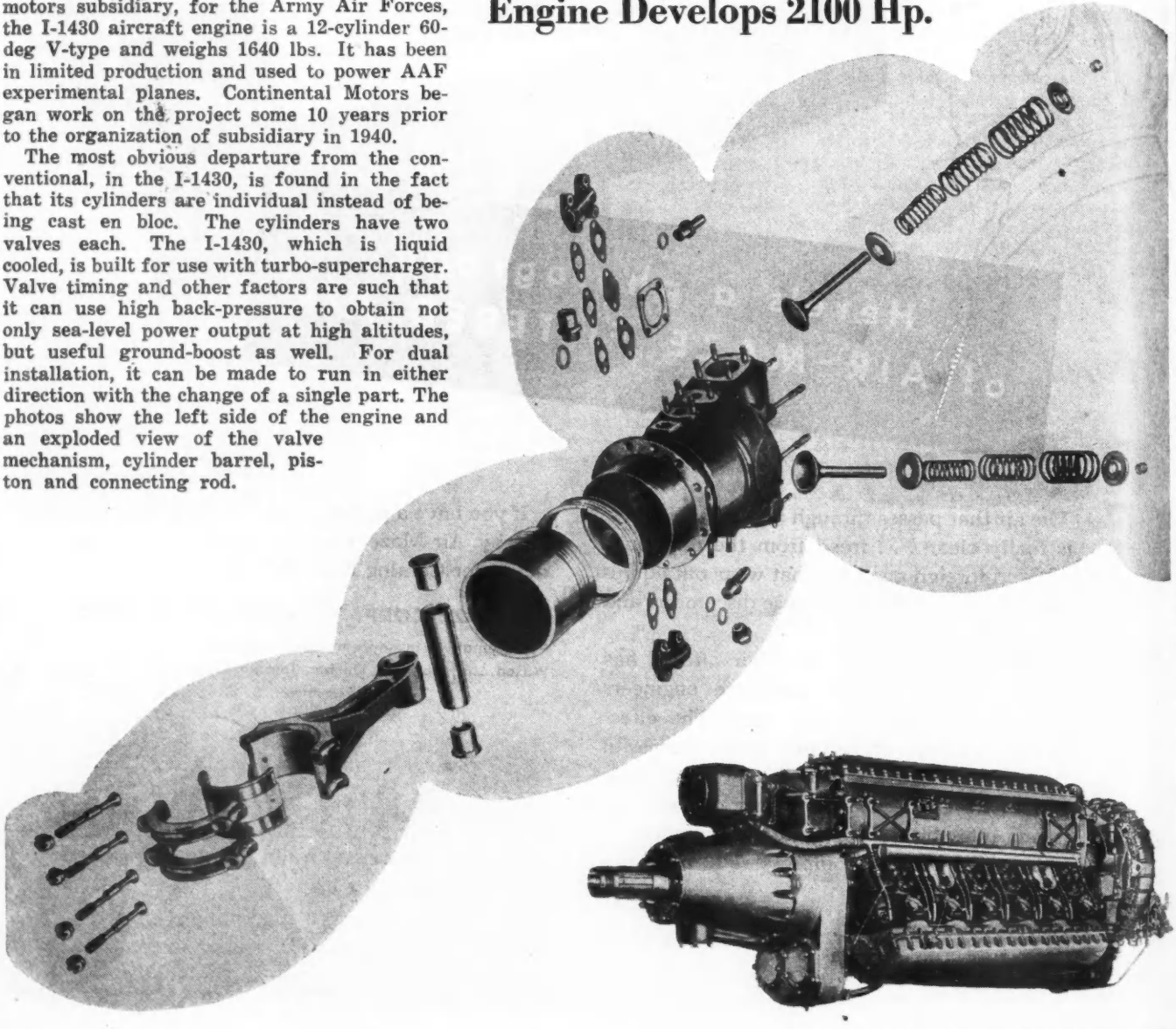


Formation stick unit

Continental I-1430 Aircraft Engine Develops 2100 Hp.

DESIGNED and built by the Continental Aviation & Engineering Corp., a Continental motors subsidiary, for the Army Air Forces, the I-1430 aircraft engine is a 12-cylinder 60-deg V-type and weighs 1640 lbs. It has been in limited production and used to power AAF experimental planes. Continental Motors began work on the project some 10 years prior to the organization of subsidiary in 1940.

The most obvious departure from the conventional, in the I-1430, is found in the fact that its cylinders are individual instead of being cast en bloc. The cylinders have two valves each. The I-1430, which is liquid cooled, is built for use with turbo-supercharger. Valve timing and other factors are such that it can use high back-pressure to obtain not only sea-level power output at high altitudes, but useful ground-boost as well. For dual installation, it can be made to run in either direction with the change of a single part. The photos show the left side of the engine and an exploded view of the valve mechanism, cylinder barrel, piston and connecting rod.



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Write for new Bulletin 43-11 which includes description of construction, operation and types of controls, installation drawings, performance characteristics, installation and operating instructions of Vickers Variable Delivery Piston Type Pumps.

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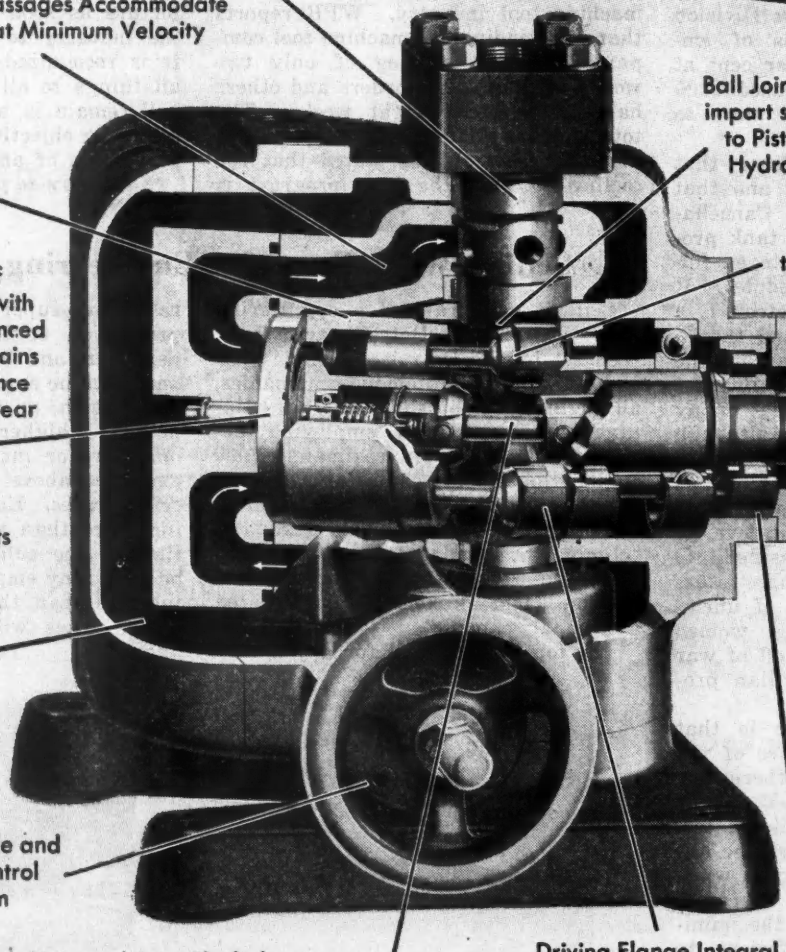
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Floating Universal Joint Shaft does not transmit Hydraulic Power load
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Ball Joint Connecting Rods impart straight line motion to Pistons and transmit Hydraulic Power load

There Are More Than 5,000 Standardized VICKERS Units For Every Hydraulic Power and Control Function

Cutbacks in Contracts for War Materials Have Hit Detroit Area

Cancellation of Construction for Tank Production Expected to Be Followed by a Reduction in Schedules

War contract cutbacks already have hit the Detroit area, the major one so far being the announcement that production of B-24 bombers will be ended at Ford's Willow Run bomber plant by Aug. 1. The reaction on subcontractors has had a widespread effect already, with Briggs Mfg. Co., Murray Corp. of America, and Briggs Division of GM laying off hundreds of employees. A cutback of 33 per cent at Hudson on P-38 wings released 1000 workers the first day, with more to follow.

There is increasing evidence that more cutbacks are to follow and that they will be rapid and rude. Cancellation of new construction for tank production recently is expected to be followed by a reduction in schedules. It must be remembered that Detroit is a great sub-contracting area and that a 12 to 15 per cent cutback across the boards will mean immediate 100 per cent cancellations for a great many small sub-contractors. And although considerable new work has been approved for the area, some of it has been choked off before production started. As a result of recent developments, Detroit has been reclassified into a group II labor area and there is expected to be a fair amount of unemployment, especially among women workers, between the falling off of war work and resumption of civilian production.

Another interesting factor is that because of the peculiar nature of the military situation in Europe there may be many cutbacks before V-E day is declared. As the enemy is liquidated, the need for war materials will be lessened and the point may come when fighting still is in progress but on a much reduced scale, so that the munitions on hand will be sufficient to finish the job. At that point, production will be evaluated in accordance with needs for the Japanese war and schedules cut back accordingly.

Although overall cutbacks during the first quarter still are officially estimated at 12 to 15 per cent, it is an open secret that WPB views this as extremely conservative and that they might run as high as 24 per cent, followed by totals of 35 per cent after six months and 50 per cent at the end of the first year.

The cutbacks so far have had only a modest effect on reconversion in the automobile industry. A more significant effect, however, is the reduction of backlogs of rated orders in the machine tool industry. WPB reports that some individual machine tool companies have a backlog of only two weeks work on rated orders and others have from six to eight weeks. The total for the industry as a whole was not given, but it was stated that the tooling job for the war program is largely completed with the exception of a few new programs. The cutback in expansion of the ammunition program was accompanied by cancellations of rated orders for machine tools. Consequently, machines for reconversion should have a much better chance for earlier delivery than anticipated a few weeks ago.

Industry has been concerned for some time about the possibility of Governmental controls being retained after V-E day for an indefinite period. After returning from a policy meeting at Washington recently, however, Carsten Tiedeman, Detroit Regional WPB Director, told a press conference that the agency wants to bow out of the picture as soon as possible and leave the industry to its own reconversion. It is recognized that WPB cannot be all things to all men, and the agency will remain in business only until the following objectives have been realized: prevention of any letdown in war pro-

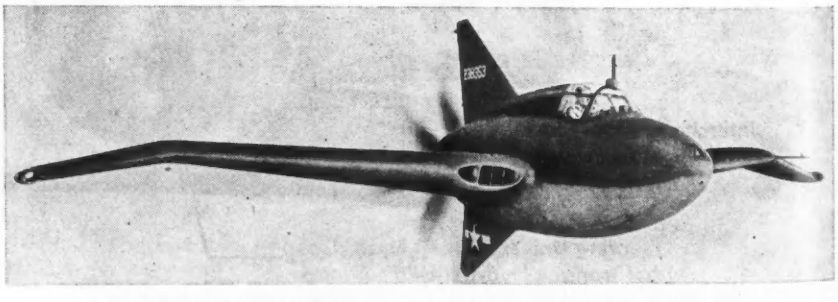
(*Turn to page* 112, *please*)

Ceiling Wage Rates for Engineering Employees

Ceiling wage rates for engineering employees in the Detroit, area have been set by the Detroit regional WLB and will apply to automobile companies, all engineering job shops, and all manufacturing companies employing designing engineers. Approximately 7000 engineering employees are affected.

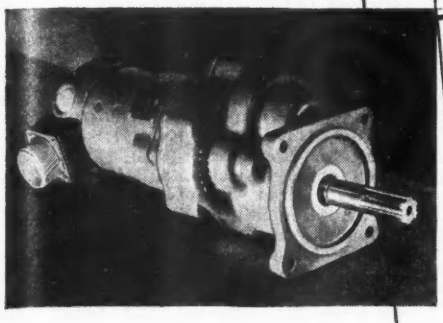
Louis C. Mariani, board chairman, stated that the ruling would gradually "eliminate the inflated rates which unstabilized the entire industry, made possible labor brokerage, and created a national scandal."

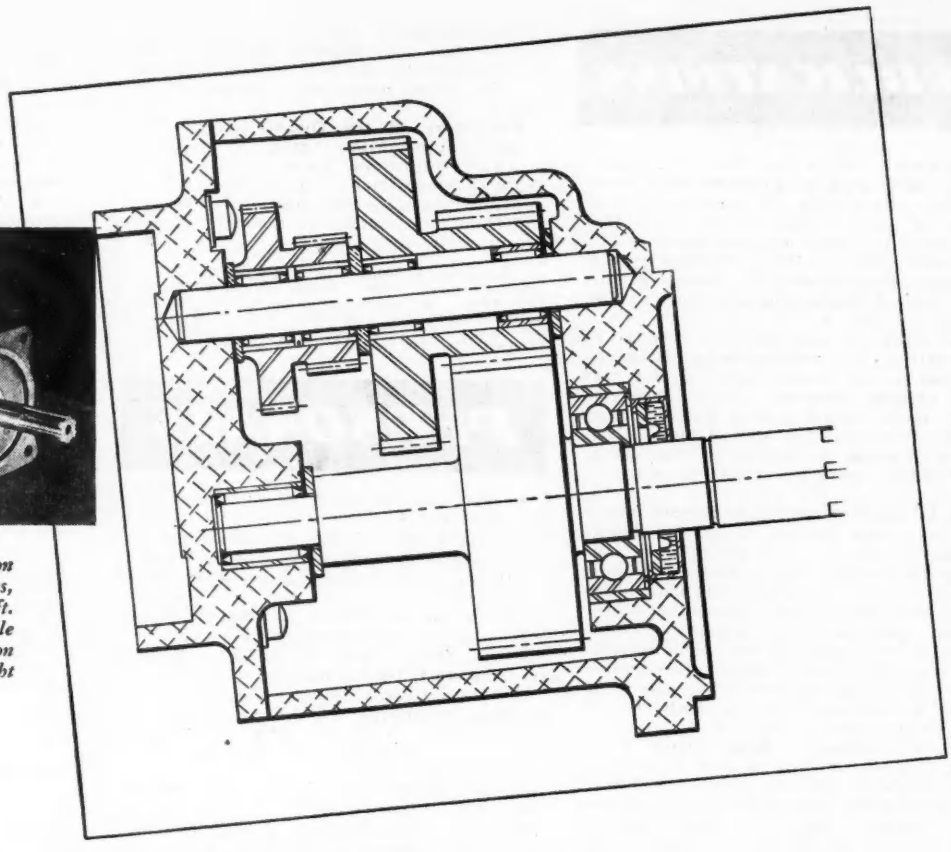
The top rate allowed for any hourly rated, non-supervisory classification of production engineering will be $2.65 per hour, and $2.45 per hour for tool and machine engineering classifications. In addition, no employer, even though he has a higher legal maximum rate, may hire or increase any engineering employee above the newly established ceiling rates. Employees legally receiving more than the new ceiling at the time of the ruling, however, may not be cut. Any employer who now is paying less than the ceiling may not increase rates without obtaining WLB approval.



Tailless Pursuit Plane with Blower Cooled Engine

Aft of the pilot's cockpit of Northrop Aircraft's XP-56, a Pratt & Whitney radial aircooled engine drives twin, three-bladed, counter-rotating propellers. Elevators and lateral controls are on the wing trailing edge, while fixed vertical fins above and below the fuselage provide directional stability. This is the first pusher type plane with counter-rotating propellers giving high thrust without torque, and is the first of its type with a completely submerged aircooled engine.





X-section shows 5 of the 7 anti-friction Needle Bearings used on Air Associates, Inc. gear reduction drive for aircraft. This is typical of Torrington Needle Bearing use to get the high anti-friction performance from small design weight and space.

Needle Bearings Give Increased Design and Operating Efficiency to Gear Reduction Drives

Torrington Needle Bearings combine unusually high load capacity into a small, compact bearing with low coefficient of friction that offers many design advantages. That's why, in the widely used gear reduction drive made by Air Associates, Inc. for the retractable landing gears, canopies and other moving parts of so many fighter aircraft, the gears and shafts turn on these modern anti-friction needle bearings.

Torrington Needle Bearings are light in weight and compact, yet engineered to stand up to high speeds and heavy loads. They also permit other weight and space savings in the design of housings and other component parts . . . are easy to install, maintain and lubricate!

Why not have these Torrington Needle Bearing advantages on the tools or machinery you design, build or operate? Our Catalog No. 32-A is packed with useful data on anti-friction Needle Bearing applications ranging from kitchen appliances to textile and agricultural machinery. You should have this helpful data in your engineering and design files. Drop us a line and we'll gladly send you a copy.

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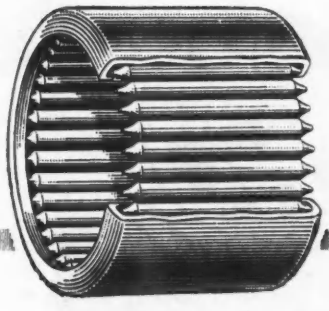


TORRINGTON NEEDLE BEARINGS

PUBLICATIONS

The Electric Auto-Lite Co. has prepared a new **spark plug specification wall chart,** featuring spark plug specifications for all makes of cars manufactured since 1933, with special listing of specifications for cars made prior to 1933. Thermal ratings and type equivalents are listed, as are recommended spark plug gap settings for all makes of cars.*

Two technical bulletins are offered by Cincinnati Milling and Grinding Machines, Inc. One covers recommendations for **high speed carbide milling,** briefly describes speeds, feeds, cutter angles and efficiency of metal removal. The second bulletin has to do with recommendations for the **grinding of cutters** for high speed carbide milling.*

How to Solve Pumping Problems, is the name of a new booklet issued by George D. Roper Corp. It is designed to aid the beginner as well as the experienced pump engineer. It gives the basic fundamentals used in estimating the requirements of the average pumping job; explains formula used in figuring suction lift and discharge head; gives information on how to estimate horsepower requirements, the size and speed of pulleys, etc. Technical charts and tables are included.*

A new handbook, **Engineering Data M-1332,** has been issued by The Cincinnati Milling Machine Co. It covers specifications, dimensions and special notes on the current line of milling, broaching and cutter sharpening machines. Information on each type of machine in the line is presented in simple form for convenient handling and reference.*

A new stock tool bulletin, No. 137, describing its line of **carbide tipped machine centers,** has been published by Tungsten Carbide Tool Co.*

The Timken Roller Bearing Co. has released a new circular slide rule, **Hardenability Calculator,** to be used in computing the approximate hardenability of steel from its chemical composition and grain size in accordance with standard formulae.*

Analyzing Job Demands and Physical Handicaps of Veterans and Civilians, is the title of a Manual prepared by Dunwoody Institute, Minneapolis, Minn. The manual and accompanying chart are designed as a help in the study of the motion demands of the jobs in any occupation in their relation to the handicaps of workers. The completed charts are 25c each and the General Manuals are 50c each. Blank work charts for use in analyzing other occupations can be had for 25c each from the Institute, 818 Wayzata Blvd., Minneapolis 3.

Continental-Diamond Fibre Co. has issued **Engineering Bulletin ED-44, Electrical Insulating Materials** which contains data on all standard NEMA grades of Phenolic Laminates, information on various types of tests and complete data on several different types of electrical insulating materials.*

The Victor Mfg. & Gasket Co. has issued the 14th Edition of the **Victor Gasket Guide.** It contains comprehensive data on all kinds of gaskets required for replacement in automobiles, trucks, tractors, buses and industrial and marine engines. New features are full numerical listings of factory part numbers with Victor numbers, special indexing for various motor models, markings of alphabetical listings to show the contents of gasket sets and a rating of gaskets and oil seals.*

A new folder describing a new line of **industrial metal cleaning materials,** designed to cover a wide range of specific applications has been issued by The Optimus Detergent Co.*

A new Size List (No. 20), on lubricant-retaining bearings, has been published by Bound Brook Oil-Less Bearings Co. In addition to tabulations of graduated dimensions, segregated for quick reference on sleeve type and flanged bearings, other data on self-aligning bearings, thrust washers, bar stock and special shapes are included.*

The Story of the Diesel, published by Diesel Engine Mfg. Assoc., tells of the postwar future of Diesels, their many fields of applications, etc. It is written in non-technical language and copies may be had from the association, 1 North La Salle Street, Chicago 2.

* Obtainable by subscribers within the United States through Editorial Dept., AUTOMOTIVE and AVIATION INDUSTRIES. In making requests for any of these publications, be sure to give date of the issue in which the announcement appeared, your name and address, company connection and title.

PERSONALS

Recent Appointments among Automotive and Aviation Manufacturers:

Udylite Corp., **Arthur A. Schuenemann,** Metal Finishing Service Engineer; William H. Moyer, Phila. representative and service engineer.

DeSoto Motor Corp., **George H. Bann,** Mgr. new Syracuse Sales Office.

Dodge Bros. Corp., Truck Div., **Russell H. Dragsdorf,** Operating Mgr.

Chrysler Corp., Dodge Div., **Dan B. Mooney,** Pittsburgh Asst. Regional Mgr.

The Landis Tool Co., **Walter P. Lotz,** Mgr. Eastern Sales Office, headquarters in New York City.

Graham-Paige Motors Corp., **E. Peerce Lake,** General Sales Mgr.

Willys-Overland Motors, **Stanley Hawley,** Works Mgr., Automotive Div.

Packard Motor Car Co., **G. H. Brodie.** Asst. to the President in charge of special design projects.

The White Motor Co., **Walter G. Auer,** Regional Wholesale Mgr., Northern California and Nevada, with headquarters at San Francisco. **Rolla W. Moore,** Mgr., Portland Branch, succeeding Mr. Auer. **D. H. Wilson,** Regional Wholesale Mgr., Washington and Northern Idaho, headquarters in Seattle.

United States Rubber Co., Textile Div., **R. C. Harrington,** Technical Director charge of development, engineering, etc.

Mack-International Motor Truck Corp., **John Walker,** Mgr., Sales Engineering Dept.

The Goodyear Tire & Rubber Export Co., **R. D. Thompson,** Mgr., and **Ivan B. Goble,** Asst. Mgr., Tire Dept.

General Electric Co., **J. E. N. Hume** and **J. W. Belanger,** Asst. Mgrs. of Sales, Apparatus Dept.

The B. F. Goodrich Co., **Ward Keener,** Asst. to the President; **Dean E. Carson,** Director of Business Research.

Lindberg Engineering Co., **Norbert K. Koebel,** Mgr. of Sales.

United States Rubber Co., General Products Div., **Howard W. Kelsey,** Sales Promotion Mgr.

Westinghouse Electric & Mfg. Co., **Ellis L. Spray** elected vice-president in charge of elevator and air conditioning activities, headquarters at Jersey City.

Bliss & Laughlin, Inc., **L. E. Meidinger,** retirement after 31 years as district mgr. at Milwaukee. **R. L. Mitenbuler,** sales representative for State of Wisconsin, with headquarters at Milwaukee.

Inland Rubber Corp., **James H. Higgins,** General Project Mgr.

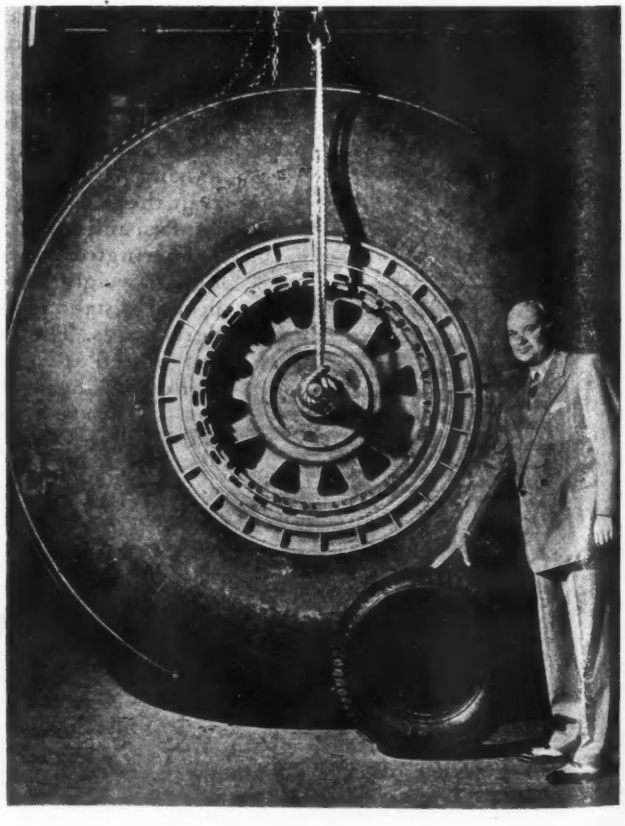
The Hydraulic Press Mfg. Co., **Col. H. A. Toulmin, Jr.,** Chairman of the Board and President. **Howard F. MacMillin,** formerly president, elected President of H-P-M Development Corp., a subsidiary of Hydraulic Press Mfg. Co.

Lincoln Award Program

It is the purpose of The James F. Lincoln Arc Welding Foundation $20,000 Award Program to encourage, by the offer of monetary and other rewards to authors, the preparation and publication of textbooks, one on modern machine and another on structural design by all processes, including welding, for the instruction and study of engineering undergraduates. In any rapidly advancing engineering field there is usually a substantial delay be-

Experimental Airplane Tire

This huge tire measures 9 ft, 2 in. in overall diameter, 44 in. across the beads, and 36 in. from one sidewall to the other. Weight of the tube is 250 lb, and the tire, with its tube and rim, weighs 2600 lb. Built in the plant of the Goodyear Tire and Rubber Co.



(Advertisement)

The CONE AUTOMATIC MACHINE COMPANY sees many GOOD THINGS AHEAD

It is reported that . . . . . .

Ball bearings, for precision equipment, are now made with outside diameter as small as two millimeters. *Science News Letter.*

get ready with CONE for tomorrow

The first cotton crop to be harvested entirely by machine has recently been reported. The result seems to be a lower grade of cotton offset by reduced cost. *Time.*

get ready with CONE for tomorrow

Postwar automobile wheel rims are to be wider, or about three-fourths of the tire width. *National Wheel Rim Assn.*

get ready with CONE for tomorrow

The combined use of the electron microscope and the three-dimensional vectograph is making possible better observation of the structure of metals and consequent improvement of alloys. *Dow Chemical Company.*

get ready with CONE for tomorrow

A new product is intended to seal the spaces between spot welds and make a continuous liquid-tight joint. *Presstite Engineering Co., St. Louis.*

get ready with CONE for tomorrow

A new system of aircraft engine lubrication is claimed to supply an adequate flow of oil as high as 45,000 feet. *Penn. State College and Sharples Co., Phila.*

get ready with CONE for tomorrow

The number of persons employed in individual research laboratories just about doubled in the ten years ending in 1940. *G. Edward Pendray, Asst. to President, Westinghouse Electric & Mfg. Co.*

get ready with CONE for tomorrow

A new process of adding carbon black to liquid rubber latex will, it is hoped, reduce the cost of tires and add to their service. *General Tire & Rubber Company.*

get ready with CONE for tomorrow

It is claimed that one of the new rechargeable flashlight batteries will outlast 400 of the usual dry cell type. *B. F. Goodrich Co.*

A new 4 by 6 foot "tectonic" map of the United States shows the complete geologic structure of the country and is said to be the first of its kind ever published. *American Assn. of Petroleum Geologists.*

get ready with CONE for tomorrow

A new device called the "Odograph" automatically makes a map, in any scale, of a road while being carried in a fast-moving automobile. *U. S. Army Engineer Corps.*

get ready with CONE for tomorrow

A jet propulsion drive for torpedoes has recently been patented. *Science News Letter.*

get ready with CONE for tomorrow

A portable electrostatic air cleaner is used to precipitate the smoke produced by welding. *Westinghouse Electric & Mfg. Co.*

A manual of instruction in the making of aerial "highway signs" for the guidance of aircraft has just been published. *Civil Aeronautics Administration.*

get ready with CONE for tomorrow

The Combined British Astronautical Societies have designed a "space ship" in which they propose to send three men to the moon in about 48 hours. *Electronic Markets.*

get ready with CONE for tomorrow

An automobile manufacturer is already planning the assembly-line production of helicopters. *Nash-Kelvinator Corp.*

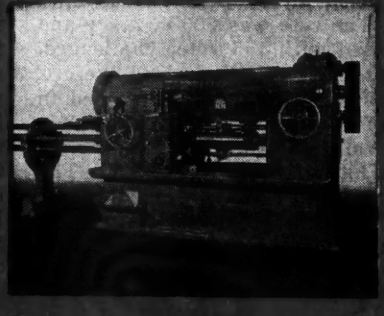
get ready with CONE for tomorrow

A new material for shoe soles is said by the maker to be lighter and more durable than leather and resistant to oil and water. *B. F. Goodrich Co.*

get ready with CONE for tomorrow

More than 80,000 farmers obtained government priorities to electrify their farms, in 1943, as a means of increasing food production. The 1944 total will probably reach 120,000. *EMPIC No. 8.*

This machine cuts its own weight in metal in four days



3½" 6-Spindle Conomatic

To produce the part shown, 6 pounds of chips — over a sixth of a ton of metal per hour — were removed from WD1314 bar stock.

CONE

AUTOMATIC MACHINE CO., INC. ★ WINDSOR, VERMONT, U. S. A.

17

tween process developments in industry and the treatment of these new developments in textbooks. The purpose of this Award Program is to reduce this delay in the fields of machine design and structural design and to render a service to engineering colleges and to the industries which employ their graduates.

In each of the two classes there is a first award of $5,000, second award of $3,000 and third award of $2,000.

The Foundation will announce the winners as soon as possible after the close of the program on May 15, 1946.

ASA Color Code for Lubrication of Machines

Unskilled labor can be effectively guided in applying the right grease or oil to machinery through use of a new American War Standard based on a simple system of matching colors, according to an announcement made by the American Standards Association. This war standard has been developed through the American Standards Association at the request of the National Machine Tool Builders Association and the War Production Board.

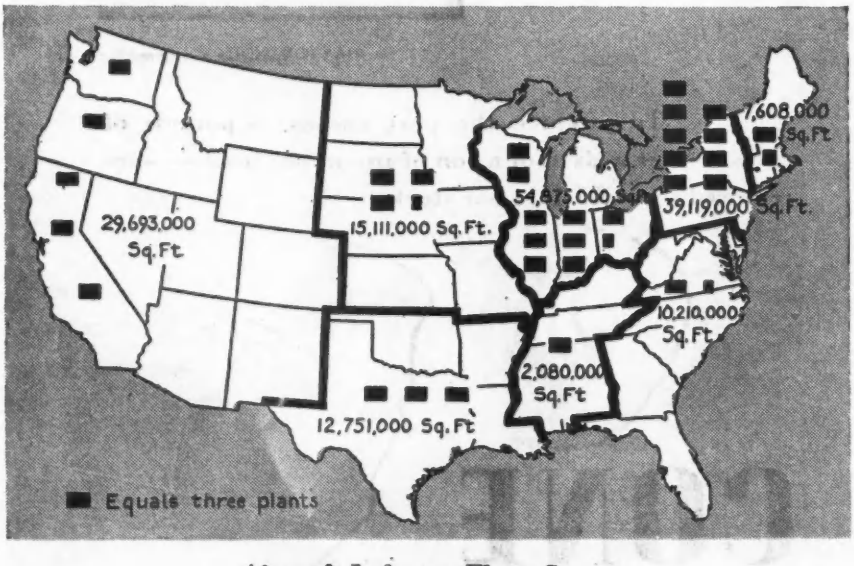
The committee in charge has worked out a basic system of color markings to be applied to the containers of a given lubricant and also to the points where each lubricant should be applied. The lubricating device, such as an oil can or grease gun, and the lubrication fitting to be serviced with it are marked with the same color, either by paint or decalcomania. Thus the service man has only to "match colors" to be sure that each lubricant is being used in the right place.

The colors for classes of lubricants are as follows: General purpose oils, brown; machine tool spindle oils, yellow green; gear oils, purple; hydraulic oils, yellow; special purpose oils, red; general purpose greases, light blue; anti-friction bearing greases, orange; special purpose greases, pink.

Packard Expected to Continue to Oppose Collective Bargaining with Foremen

Although foremen at Packard Motor Car Co. voted in favor of affiliating with the Foremen's Association of America at an election held April 17, the company is expected to stand on its previous statement that it will continue to oppose collective bargaining with foremen by all legal and proper means. The vote was 666 in favor and 534 opposed with 155 votes challenged. In a previous election held before, NLRB reversed its stand and ruled in favor of collective bargaining for foremen, all but two of the foremen at Packard had voted to join FAA. The narrowing of the margin in the last election is considered to be in the nature of a moral victory for the company, which had presented its case to the foremen a few days earlier.

While Packard officials would make no definite commitment, it is considered a foregone conclusion that the issue will be carried to the Federal Courts for adjudication. A Washington report states that 14 companies which are facing unionization of their foremen have asked WLB to postpone any further action on demands by foremen until the issue has been settled. Packard, Briggs Mfg. Co., Murray Corp. of America, and Hudson Motor Car Co. were among the companies asking for the deferment of action. The Ford Motor Co. voluntarily recognized foremen as a bargaining unit last May.



Aircraft Industry Floor Space

In 1939 aircraft manufacturing ranked forty-fourth in the list of U. S. industries. Today the industry consists of more than 100 plants containing more than 171 million square feet of floor space.

Business in Brief

Written by the Guaranty Trust Co., New York, Exclusively for AUTOMOTIVE AND AVIATION INDUSTRIES

Continuing expansion of business activity is indicated by current reports. *The New York Times* index for the final week of March stands at 144.6, a full point above the preceding weekly figure and four fractional points higher than the corresponding level last year.

Department store sales as reported by the Federal Reserve Board for the week ended April 7 registered an expected seasonal decline, standing at 181 per cent of the 1935-39 average, as compared with 230 the week before and 208 a year ago. Comparisons with last year's corresponding figures for longer periods show gains of 10 per cent for the four weeks ended on that date and 15 per cent for 1945 thus far.

Electric power production was further reduced in the first week of April and was 0.9 per cent less than in the comparable period last year, as against a similar decline of 1.8 per cent recorded a week earlier.

Railway freight loadings in the same period totaled 764,763 cars, 8.4 per cent fewer than for the week before and 2.9 per cent below the comparable number a year ago.

Crude oil production for the week ended April 7 averaged 4,783,865 barrels daily, 2450 barrels above the figure for the preceding week and 367,765 barrels more than the output a year ago.

Production of soft coal in the final week of March is estimated at 12,135,000 net tons, as against 11,850,000 a week earlier and 11,725,000 tons a year ago. Output for the entire first quarter of 1945 was 6.7 per cent below the corresponding quantity last year.

Engineering construction contracts awarded during the week ended April 12, according to *Engineering News-Record,* totaled $52,157,000, the largest weekly amount reported in 1945. This sum is 55 per cent above the figure for the preceding week, 42 per cent above the average for the four weeks preceding and 59 per cent above the total for the corresponding week last year. For 1945 to date, however, the contract total is 10 per cent below the comparable figure in 1944.

The Irving Fisher index of wholesale commodity prices, after four consecutive weekly recessions, advanced to stand on April 6 at 114.82 per cent of the 1926 average, as against 114.56 a week earlier and 112.74 a year ago.

Member bank reserves increased $240,000,000 during the week ended April 11, reflecting a rise of $508,000,000 in total Reserve Bank credit, an increase of $74,000,000 in Treasury deposits with the Reserve banks and other changes. Excess reserves remained at an estimated total of $900,000,000. During the preceding week, earning assets of reporting member banks declined for the eleventh consecutive weekly period, with a decrease of $44,000,000 in commercial, industrial and agricultural loans.

DO IT WITH A DUOMATIC

Accuracy and uniformity are essential in cutting V-grooves in V-belt sheaves. This assures proper belt seating, equal pull, and maximum transmission of power.

With the Duomatic—Lodge & Shipley's full automatic lathe—you get accuracy and uniformity PLUS exceptional speed in production. For on the Duomatic, dual carriages and tool slides permit far greater multiple tool operations, front and rear... cut many more sheaves at the same time.

Illustrations show L & S Duomatic Lathes in the light duty sheave department of the Dodge Manufacturing Corp., Mishawaka, Indiana. Multiple tools, front and rear, cut 5 V-grooves at one time in Dodge precision-built D-V Sheaves. As groove shapes and pitch diameters must be identical Duomatics are used to meet every precision requirement and to effect outstanding savings in production time.

Call on L & S Engineers to show you how the Duomatic can do a better, faster job on V-belt sheaves. For detailed literature, write on your company letterhead for Bulletin 601.

THE LODGE & SHIPLEY MACHINE TOOL CO.

CINCINNATI 25, OHIO, U. S. A.

L & S LATHES

ENGINE—TOOL ROOM—AUTOMATIC—OIL COUNTRY LATHES

Propeller Balance Problems

(*Continued from page* 32)

distribution of oil in some types of operating mechanism and error in knife-edge balancing of the assembled propeller. Since the C. G. of the propeller usually lies very close to the front cone, the eccentricity of the rear cone is of little importance in determining mass force unbalance, while that of the front cone is of major importance. Tolerances are not logically selected, in this respect, since 0.001 in. runout is allowed on the rear cone and 0.002 in. on the front cone. The front cone runout tolerance is excessively large, permitting 12.7 oz-in. unbalance in a 396-lb propeller. The C. G. may be eccentric by the full runout because the same front cones are used in balancing as on final installation, and they may be indexed 180 deg relative to the propeller, in the meantime. This error could be reduced one-half by using perfect front cones for balancing, or could be eliminated by marking the cones and indexing them the same for balancing and installation. Neither of these precautions is taken except in certain experimental test work.

The main factors contributing to mass moment unbalance are cone eccentricity, cone seating, tolerances which affect the forward tilt ond fore-aft location of the blades, tolerances on edge alignment and face alignment, propeller shaft angularity, propeller shaft unbalance, mass force unbalance of individual parts lying in different fore-aft positions, differences in forward deflection of individual blades under aerodynamic loading, errors in vertical balance of blades and non-symmetries in hub design, in some types.

Front and rear cone eccentricities are equally important in causing mass moment unbalance. With production limits of 0.001 in. runout on the rear cone and 0.002 in. on the front cone in opposite directions, the mass moment unbalance introduced on a 12-ft propeller with 1260 lb-ft^2 polar moment of inertia, assuming the cones to be five in. apart, is 435 oz-in^2.

The main factors contributing to aerodynamic forces and moment unbalance are tolerances on geometric angles at individual stations, changes in angle of zero lift and slope of the lift curve at individual stations due to tolerances on airfoil shape; and tolerances in the hub assembly which cause the blades to have different angles at the reference stations. Stations at the tip are considerably more important in determining aerodynamic moment unbalance than force unbalance. Centrifugal restoring moment has an appreciable effect in reducing aerodynamic moment unbalance, but has no appreciable effect upon any other type of unbalance.

Airplane Vibration Due to Propeller Unbalance

Propeller rotational frequencies are sufficiently high that they occur in the region where a number of aircraft structural natural frequencies, and engine and mount natural frequencies occur. A detailed study of the response of the entire structure to unbalance excitation is a very complex thing, but a qualitative insight into the problem may be obtained by using certain simplifying assumptions. For example, it is a relatively-simple matter to compute the response of an airplane in which the structure and engine mounts are assumed to be rigid.

Plotting weight and length of a large number of airplanes against total horsepower, as a parameter, and combining the values with the amounts of unbalance plotted in Fig. 1 and 2, the curves of Fig. 3 are obtained, these curves show relative amounts of roughness to be expected with typical one-, two- and four-engined airplanes and typical propellers, as a function of total horsepower. For single-engined airplanes, mass force unbalance tends to be of most importance below, and mass moment unbalance above, 950 horsepower; total roughness from all types of unbalance tends to increase with horsepower. For multi-engined airplanes, the individual propellers are of smaller horsepower for a given total power than with single-engined airplanes and have, in general, less than a proportionate amount of unbalance so that overall roughness is reduced. For two-engined airplanes, mass force unbalance is of most importance below, and aerodynamic force unbalance above, 5500 hp. Over-all roughness is more or less independent of size up to 5500 hp but probably increases with much higher powers. For four-engined airplanes, mass force unbalance is of most importance up to about 12,000 hp and aerodynamic force unbalance, above. Over-all roughness decreases slightly with power up to 10,000 hp but probably increases at very high powers. These figures should represent general tendencies in actual airplanes, although it must be borne in mind that particular cases vary widely because of the different types of resonance involved.

In the tabulation below, a comparison is made of the double amplitudes of vibration calculated for the airplane with both rigid and flexible engine mounts.

DOUBLE AMPLITUDE OF VIBRATION—THOUSANDTHS OF AN INCH

	Rear of Fuselage				Pilot's Seat			
	Lateral		Vertical		Lateral		Vertical	
	Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	Rigid	Flexible
Force	0.228	1.800	0.476	0.380	0.1364	0.710	0.0526	0.144
Moment	0.219	2.160	0.318	0.167	0.073	0.720	0.106	0.0432
Combined	0.4474	3.960	0.794	0.547	0.2094	1.430	0.1533	0.1872

It is seen that the lateral vibrations have been increased from an insignificant level to a very noticeable level by the yawing resonant characteristics of the engine, while the vertical vibrations have been generally somewhat reduced. Because the vertical and pitching frequencies are well below the operating range, a certain degree of vibration isolation is effected. If the lateral and yawing frequencies could have been reduced to comparable values by redesign, the airplane would have been quite insensitive to propeller unbalance. In general, it is desirable to select engine mounts of such stiffness as to place the frequencies of natural modes of vibration, which may be excited by propeller unbalance, outside the propeller speed range, preferably on the low side. These modes always include lateral, vertical, yaw and pitch, and may include roll when the elastic center does not coincide with the shaft axis; and either roll or fore-aft when elastic coupling exists with other modes.

For simplicity, the previous discussion has been limited to the study of hypothetical airplanes with rigid structures. Actually the problem is vastly complicated by the existence of numerous complex resonances in the propeller frequency range. Higher modes of vertical wing bending, fundamental fore-aft wing bending, fuselage side bending, fuselage vertical bending, horizontal stabilizer bending, and vertical stabilizer bending natural frequencies commonly occur in the range. Motions of the control surfaces associated with these primary structural modes of vibration couple the control systems with the rest of the system. Thus, vertical oscillations of the horizontal stabilizer and elevators cause fore-aft motion of the stick, which may be greatly accentuated by resonant characteristics of the stick-elevator system. Lateral oscillations of the vertical stabilizer and rudder cause fore-aft motion of the rudder pedals, and vertical oscillations of the wings and ailerons cause lateral motion of the stick. Localized resonances may occur at various places in the airplane excited by the motion of the main structure. Thus resonances of the instrument panel on its rubber mounts or of other elastically mounted equipment, or bending resonance of a control column, may cause trouble.

Structural modes are always such that maximum amplitude occurs at one or more of the extremities. Thus fuselage bending modes are such that the nose and tail are rough while

(*Turn to page* 52, *please*)

Are you Taking Advantage of *this* Carpenter Service?

Here is an on-the-job story of how Carpenter Stainless Strip and the practical knowledge of a Carpenter representative teamed up to overcome production difficulties and lower costs in making Stainless parts.

The inside diameter of the typewriter key rims shown above had to be formed exactly to size so that they fit tightly over the keys. Sharp corners at the base of the tab were essential, since if the tabs were not properly stretched or drawn, the bend would come at a point below where the tab joins the rim. This would have made it impossible to secure a tight fit.

Recommendations of the Carpenter representative helped solve the shop difficulties. And here's what the manufacturer gained by using Carpenter Stainless Strip: 1. Because Carpenter supplied Stainless Strip in long coils to very close tolerances, it permitted faster and more economical manufacture than was possible with the metal previously used. 2. A change-over from non-ferrous metals to Carpenter Stainless Strip also made possible a saving in initial cost of the material because Stainless was 12% lighter in weight. 3. And further, Carpenter Stainless Strip was less costly to ball burnish to bring out the gleaming finish on the part.

It will pay you to investigate the possibilities of applying ductile, easy-working Carpenter Stainless Strip to your new or redesigned products. Your nearby Carpenter representative will be glad to stop in and discuss with you ways of getting the most from this versatile Stainless Strip.

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modes and smaller amplitudes occur in the middle portions. In a single-seat airplane, the vibration of the pilot's seat is generally small compared with that at the tail, so that vibration is likely to be felt in the stick or rudder pedals rather than in the seat. In bombers, the pilots are likely to be seated in regions of relatively-small vibration; whereas, the bombardiers and tail gunners are subjected to maximum vibration. In most transports, the pilots are seated near the nose and are subjected to maximum vibration; whereas, the passengers are likely to be in regions of small vibration.

Generally speaking, it appears that most cases of propeller unbalance roughness can be cured by proper design of the engine mounts or redesign of parts of the aircraft which exhibit troublesome localized resonant characteristics. In cases where this is not a satisfactory cure, it is necessary to resort to field balancing of installed propellers. Complete force and moment balance is unnecessary complicated and involves the use of impractically-large correction weights. Mass force balancing of the vibration of the structure is more feasible and can generally be accomplished by simple means.

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Aviation Fuels—What the Airlines Want and Expect

By Gilbert K. Brower
Chief Materials Engineer, American Airlines, Inc.

THE ASTM Tentative Specifications for Aviation Gasolines, Designation D-615-41T, represent the basic requirements as to fuel quality. For the most part, the standards contained therein are acceptable with a few exceptions.

In regard to color, the airlines want identifying colors for the various fuel grades but do not want any more dye than now used in the present 91 fuel, and the dye must be stable. Clear base fuels should have a color of plus 21, minimum, since we have no satisfactory experience on fuels not meeting this requirement.

An oxidation resistance test which would be a variation of the present bomb test is recommended as the best available approximation of stability characteristics of lead-treated and inhibited fuels. Since both lead precipitation and gum formation are autocatalytic, the amounts of precipitate present after certain types of storage, handling, exposure to light, etc., preclude the possibility of a simple routine test to predict present and future condition of a fuel. Sixteen hours at 100 C and 100 psi oxygen does not appear unreasonable for the revised oxidation test.

Prewar volatility characteristics will be desired with perhaps a slight increase for the 50 per cent limit. You can expect a 10 per cent limit of 158 F, a 50 per cent of 221 F and a 90 per cent of 257 F, with other factors such as the sum of the 10 and 50 per cent points, per cent loss and residue remaining the same.

Knock-rating procedures are actively being investigated. With the advent of many new high-octane blending agents and methods of refining which result in fuels of differing hydrocarbon compositions, test methods must be revised to prevent acceptance of unsatisfactory fuels and yet not be unduly restrictive. A method of rating fuels under the complete range of fuel/air mixtures found in service is one of the problems requiring an answer. At least, a method which will give comparative mixture response data, as well as information relative to temperature-sensitivity characteristics, is needed.

Flight tests were conducted by American Airlines in November, 1944, for the evaluation of engine fuels then being supplied. Three fuels were compared —a fuel of 91 octane with 1940 commercial airline volatility character-

(*Turn to page 54, please*)

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istics; another of 91 octane rating meeting, essentially, prewar Army and current Army-Navy 91 octane distillation limits; and a third of 100 to 130 grade, also with the less-volatile limits. By comparison with higher volatility fuels it was found that a power loss of from 13 to 19 per cent was sustained with the less volatile fuels then specified. This was probably due to the poor distribution of the latter fuels in the engine. In order to have knock-free performance at the same power with the less volatile fuel, the fuel-air mixture ratio had to be increased from 0.072 to 0.076 with a carburetor air temperature of 100 F. This adds one cent per gallon to the fuel bill. By 1954, this would mean an annual loss of $5,000,000 to the air transport industry. It was concluded that the volatility characteristics, as judged by the distillation limits, are of major import as related to power losses at a given fuel/air ratio. This is due to poor distribution of the fuel with attendant lower knock-limited performance.

What grade fuels do the operators expect to purchase? My interpretation of the trend is that the bulk of aircraft engine fuels will, for five to 10 years, be grades 91/96 and 100/130 with some possible demand, to cover special operating conditions for a grade higher, say one similar to the prewar iso-octane plus 0.8 ml TEL per U. S. Gal.

The Valuation of Better Fuels

By Earle A. Ryder,
Consulting Engineer,
Pratt & Whitney Aircraft Div.,
United Aircraft Corp.

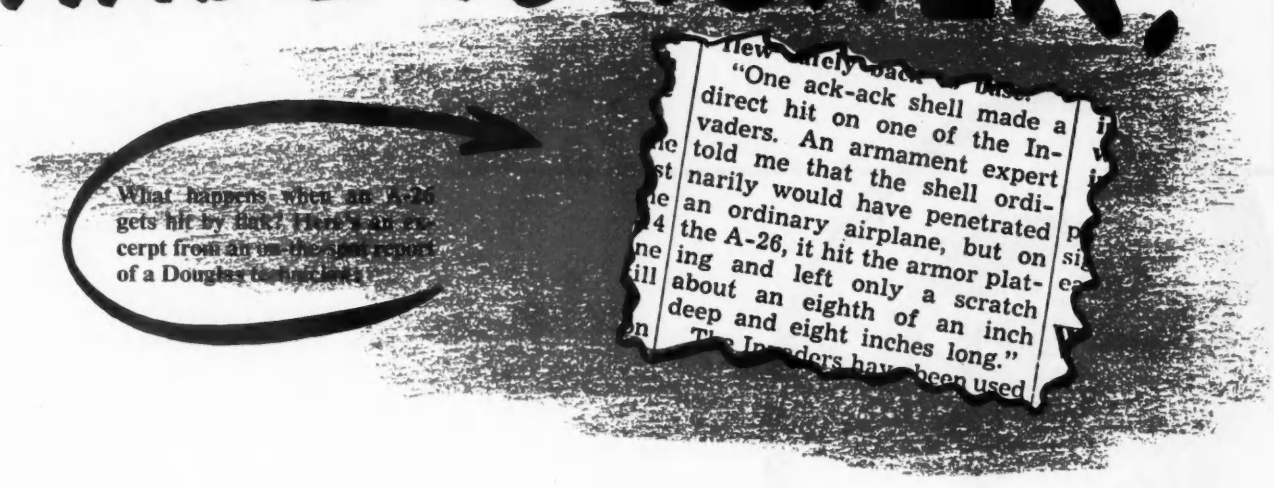
THE only substantial difference between one quality fuel and another will be in knock value. Although engine ratings are generally limited by the mechanical strength of the unit and its component parts making it inadvisable to increase these ratings through the use of higher knock value fuels, an increase in take-off power and cruising fuel economy can be realized with the use of better fuels if knock rating has been a limiting factor.

It appears that 91 octane will be a base fuel and the cheapest one available for commercial air transport. More expensive fuels cannot be justified for most short-run operations of 750 miles, or less. For flights of more than 1500 to 2000 miles, non-stop, the savings made possible by high anti-knock fuels will begin to pay, and a considerable premium can be afforded for better gasoline.

As a matter of record, it might be well to review the preferable properties for aviation fuels as follows: Fewest possible standard grades; no lead, or as little as possible; non-corrosive to metal or rubber; adequate storage stability; well-balanced volatility; absence of foreign material, gums, etc.; maximum calorific power; standardized physical properties; highest knock value suitable for the particular operation; and, low-

(*Turn to page* 58, *please*)

MADE TOUGHER!


What happens when an A-26 gets hit by flak? Here's an excerpt from an on-the-spot report of a Douglas technician:
"One ack-ack shell made a direct hit on one of the Invaders. An armament expert told me that the shell ordinarily would have penetrated an ordinary airplane, but on the A-26, it hit the armor plating and left only a scratch about an eighth of an inch deep and eight inches long."

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R301 today leads the field in usefulness . . . reward for the pioneering spirit which distinguishes Reynolds and Reynolds engineers.

Production-Wise . . . R301 in solution heat-treated temper is stable and more workable than any other high-strength aluminum alloy in the corresponding temper—thereby eliminates costly post-forming heat treatment and consequent distortion. Produced in three tempers. Wide range of uses.

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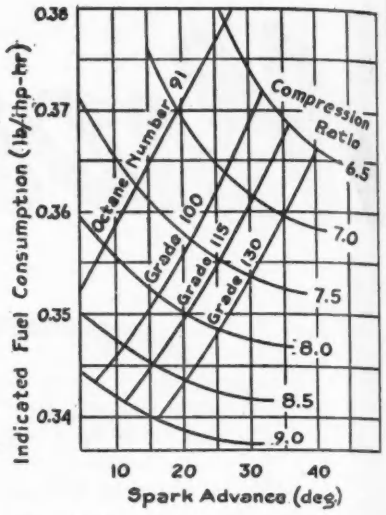


Fig. 4. Variation of best economy fuel consumption with compression ratio and spark advance

est price for the quality required. The manner in which some of these properties affect engine performance is illustrated in the following tabulation:

Maximum Power by Octane Number; Maximum Economy by Calorific Value, Volatility; Vibration by Volatility; Durability, Dependability by Ring Sticking, Burning, Bearing Corrosion; Starting, Acceleration by Volatility; Cold Weather Performance by Volatility; Hot Weather Performance by Volatility and Temperature Sensitivity.

When a substantially-better fuel is made available, the engine builder will probably take advantage of it by slightly raising the comparison ratio of the engine to obtain better cruising economy. With the present ratio of about 6.7 to 1, current fuels have inadequate knock value in well-supercharged engines, particularly at the lean-end of the mixture range. Better fuels will aid here.

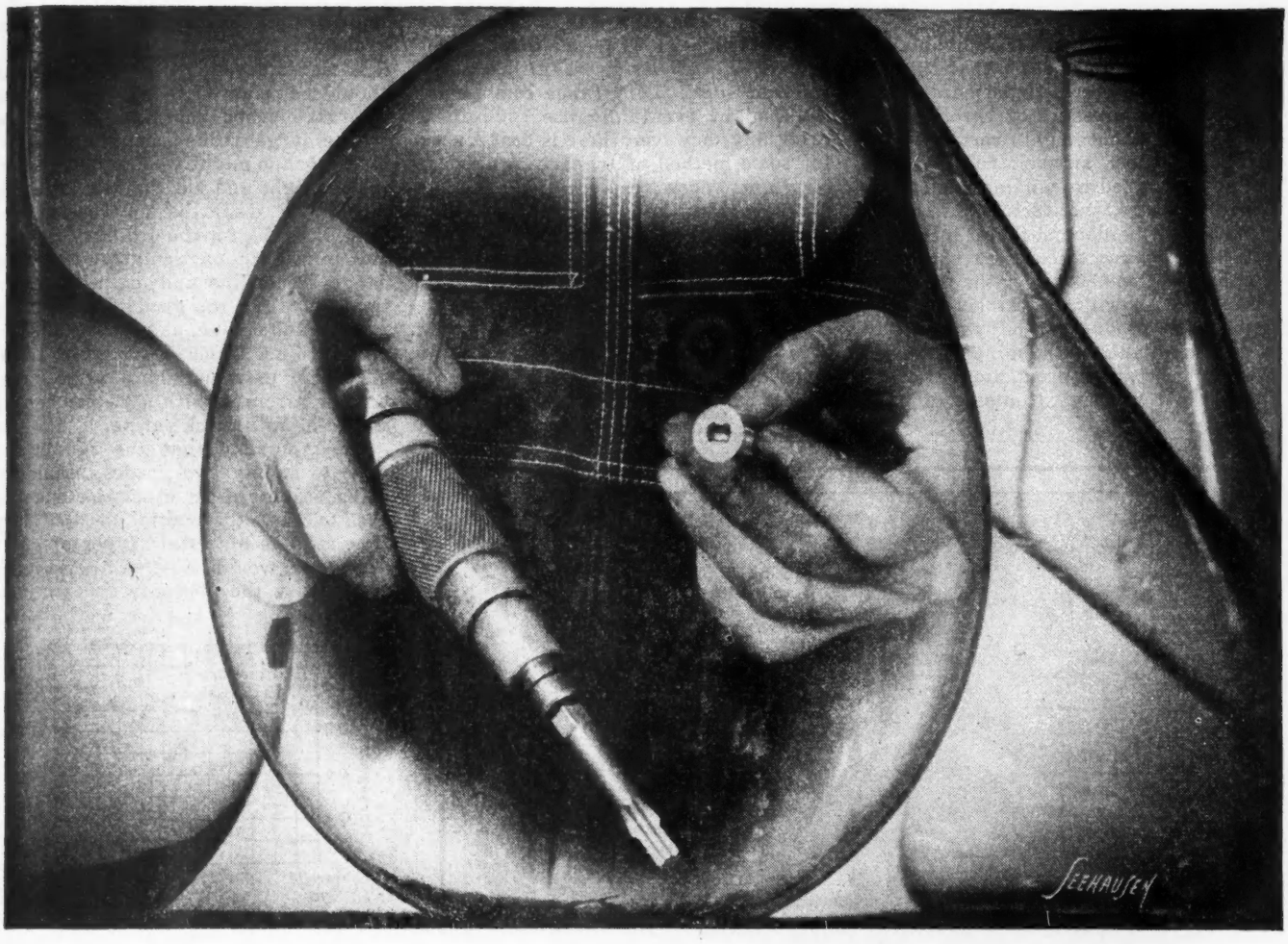
By combining relationships of fuel grade, knock value, spark advance, compression ratio and fuel consumption, a chart can be plotted showing the interdependence of these various factors (Fig. 4). With such a chart, one can determine what change in compression ratio would be permitted by a given improvement in knock value of the fuel and the gain in fuel economy which would accompany such a change. Also, the effect of changing from 100 to 91 octane fuel, and the extent to which this could be compensated for by a change in spark advance, can be determined. This chart can be interpreted for general use as it does not refer to any specific engine but to the trend of the various factors.

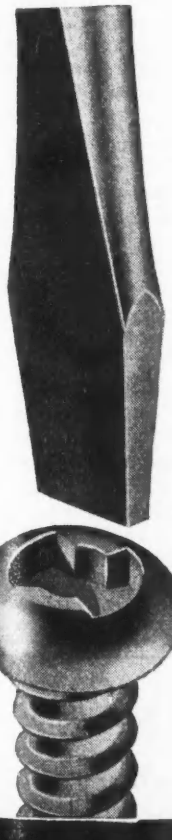
Aircraft Fuels of the Future—Supplier's Viewpoint

By Dr. R. T. Goodwin, Manager, Central Aviation Dep't, Shell Oil Co., Inc.

A FUEL of relatively-low boiling range is required, certainly not above 300 F for the 90 per cent point. Some

(*Turn to page 60, please*)





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- ★ The unmatched tool economy of the Type "A" Bit which drives home extra thousands of screws, *uninterruptedly* . . . and which may be repeatedly reconditioned to original efficiency by a 60-second application of the end surface to a grinding wheel.
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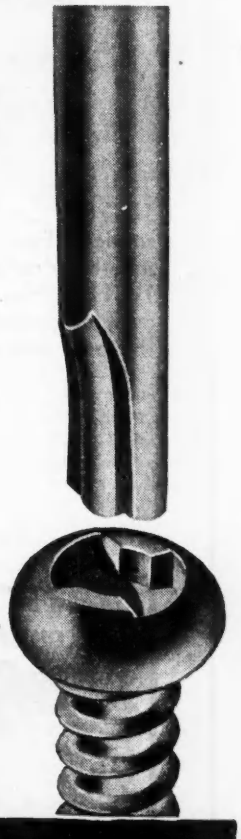
CLUTCH HEAD *Screws, sample of the Type "A" Bit, and illustrated Brochure. These will be sent you* by mail *and without obligation.*



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latitude might be allowed if the fuel is injected into each cylinder, individually; however, it does not seem that this allowance can be great. Experience shows that a vapor pressure of seven psi of the fuel is about right, certainly not more, and most aircraft fuel systems are now designed to handle fuels of this vapor pressure, satisfactorily.

What can be done through increased anti-knock characteristics is shown in Fig. 5. Developments over the past few years have shown the petroleum industry how to produce fuels synthetically of very high anti-knock value. However, the higher cost of production of these fuels is not warranted outside of military operations even with allowance for any possible gain of power through improved engine design to utilize these superior fuels. Long-range commercial lines might eventually use such fuels profitably; however, there is first a need for some method of translating laboratory anti-knock results into terms of flight performance. Projects are now under way which promise success in the solution of this problem. It is hoped that before long, flight performance, as limited by anti-knock value, can be calculated from small-scale laboratory data and thus the true worth of increased anti-knock value be obtained. Such a basis is a sound one for calculating price differentials between different grades of fuel.

A maximum of five grades is all that should be required to service the whole aircraft market from the light airplane to the large trans-oceanic liner. The lowest grade might well be an 80 octane for the light and medium aircraft. The next grade would be a 91 octane, possibly 92 or 93, for the ordinary commercial aircraft, particularly the short range feeder-line and main-line operations. The two top grades would be the present 100 octane, as now specified for military use, and a possible higher grade for extremely-long-range, trans-oceanic aircraft, with a 20 per cent increase in anti-knock rating.

It is possible that the refiner will have to supply two grades, stable and extra stable, of an otherwise identical fuel to meet the special need of long-time storage of certain types of operation. This would be necessary so as not to penalize the operator not requiring the extra stability with the higher cost of such special fuels.

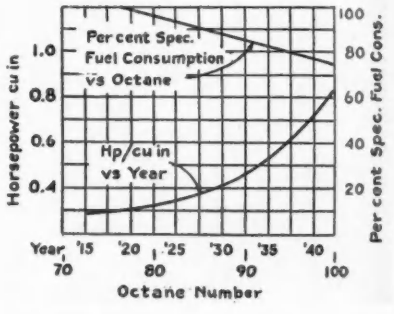

Fig. 5.—Improvement in performance with octane number and date. (Octane number scale is adjusted comparable with approximate date of introduction)

There has been some speculation as to whether light planes could use ordinary motor fuel. The principal difficulty would seem to be in the great difference in the vapor-pressure requirements of the airplane engine and the automobile. It might be interesting to have the reactions of the light-plane engine manufacturers on the possibility of using motor fuel of about 80 octane containing approximately 2 cc's of tetraethyl lead per gallon and having a vapor pressure as high as 12 psi; the 90 per cent ASTM distillation point would be as high as 392 F. Such a fuel would be made almost entirely from cracked stocks but there is no reason to believe that they would be unsatisfactory of themselves.

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First Steps Toward Reconversion

(*Continued from page* 17)

sulted. The industry is determined to press vigorously for action on this point since it would avail nothing to obtain the limited number of new machines if the company-owned tools are not freed of war work. The situation in regard to buying surplus machines is little better. One company has been negotiating since last August for surplus Government-owned machines in its plants and has had no success. Of the estimated 600,000 machine tools owned by the Government, about 50,000 are said to be surplus.

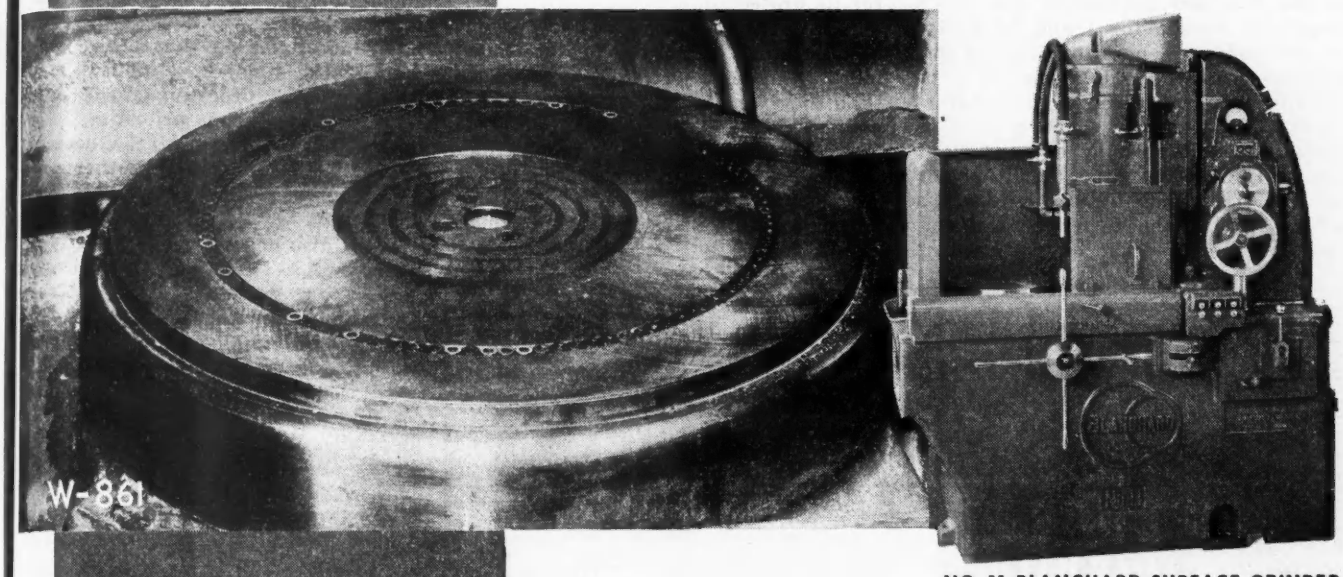
A complicating factor is that inventory lists of Defense Plant Corp. and other owner agencies and the Armed Services are in such a mess that they are practically worthless so far as indicating which machines are suitable for use in car manufacture. Here again the industry will vigorously request that the lists be cleaned up and made usable.

The Automotive Council for War Production also is taking action to find needed machines for the car manufacturers. A committee has under consideration a plan by which each manufacturer will submit a list of machines which he needs, because those he had figured as available in his original estimate to WPB are tied up or otherwise unusable. The list will then be circulated through the industry so that companies having surplus tools in their plants of the type needed may offer them if company-owned, or inform the ACWP of Government tools available from the contracting agency.

Materials are considered the next in importance to machine tools and if the machine tool program works out as planned may become the No. 1 problem. In fact, industry men say that it is the availability of materials that will determine when authorization to resume car building will be given and whether production will be unrestricted or on a quota basis. The materials section of WPB now is making a study of what materials will be available over and beyond the needs of the Japanese War and any predictions as to a possible date for Go-Day will not be possible until the study is complete. Present indications, according to Nelson, point to a tight situation in some chemicals, which will affect paint of the type used on automobiles, and in upholstery cloth, for example. A substitute paint might be developed, he said, and there are plenty of facilities and raw materials in the textile industry to provide upholstery cloth if the manpower can be found. Lead, tin, and several other materials are on the list of items that may be found to be a limiting factor in car production when the survey is completed.

(*Turn to page* 64, *please*)

"Put it on the Blanchard"



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This hardened steel washer is only 11/32″ in diameter and is so small that it has to be located over one of the brass rings in the chuck face. Two steel rings are laid on the chuck and 109 of these washers are placed between them.

.003″ of stock is removed from each side to limits of ±.0005″ and .0005″ parallel. 300 pieces (600 surfaces) are produced per hour.

Production depends on handling time, and these figures are the actual production of a good operator but are not necessarily the maximum possible.

Send for your free copy of "Work Done on the Blanchard", third edition. This new book shows over 100 actual jobs where the Blanchard Principle is earning profits for Blanchard owners.

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Plant clearance is not considered as a serious problem as it was last fall and industry leaders expect no great disagreement with Government agencies on this point. The industry was instrumental in sponsoring a proviso in the Contract Settlement Act which precludes, except for fraud, a review by the Auditor General of contract settlement deals made between the contracting agency officer and manufacturer. Consequently, once a deal is made, work on clearing out the plant can start at once without waiting for an OK from the Auditor General's office. Under the terms of the act, the Government must have the plant cleared out within 60 days after a satisfactory inventory has been submitted by the contractor. If not cleared in that time, the manufacturer can move the property out at Government expense, taking reasonable precautions for its protection.

Many wrinkles have been ironed out of procedures and both sides are much more competent to handle clearance than they were nine months ago. It is estimated that it will take from one to six weeks to prepare the inventory, depending on the size and complexity of the contract and whether a pre-termination plan has been followed, which allows setting up a formula beforehand so that on termination day most of the work is done.

The tool and die situation is in good shape, according to men in the industry. There is considerable capacity available especially in the smaller shops and recent cutbacks in munitions programs will make sufficient capacity available so that needs can be met by the time other phases of the reconversion program are ready. Granting of AA-3 priorities, if required, also will insure the necessary tools and dies as well as other equipment such as welders, conveyors, spray booths, etc.

WPB also has approved priority ratings of AA-3 for construction work necessary to get plants back into shape for manufacture of automobiles. This includes providing turnaround space, knocking out or restoring walls, installing assembly lines, etc. Applications totaling about $35 million have been filed with WPB by the automotive industry and have been approved. Priorities will be granted on materials and manpower for the work available. Approval also has been given for rehabilitation of tools.

Experimental work, drafting of engineering specifications, elimination of "bugs" from 1942 models, plant layout and similar preparatory work for which War Manpower Commission granted manpower last fall are understood to be nearly completed. Although considerable experimental work has been done, manufacturers still are sticking to their previous announcement that new cars will be fundamentally 1942 models, mechanically at least, with modifications in styling, upholstery, hardware, etc. Undoubtedly the cars will be changed in appearance, although not radically, but engines, clutches, transmission and other chassis mechanical equipment will be largely the same as prewar.

Chevrolet Propeller Blades

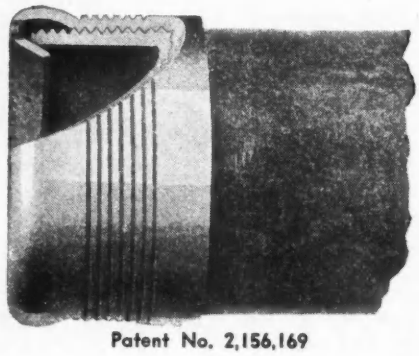
The Chevrolet Motor Division of General Motors Corp. has now produced and shipped more than half a million propeller blades for various types of military airplanes. On the basis of three propeller blades each, the output would be sufficient to equip more than 190,000 plane engines—a very large percentage of the total annual production of aviation engines during both 1944 and 1943.

Airplane propeller blades have been a principal Chevrolet war product, produced in one of four aluminum forge plants.

Filmonize Cellophane Tape

An item stating that Filmonize cellophane tape is available without priorities appeared in the Feb. 1 issue of AUTOMOTIVE AND AVIATION INDUSTRIES. The manufacturer of this product has since advised us that this availability without priority applies only to users engaged directly or indirectly in a war industry.

Use LIGHTER walled pipe Plus WEDGE Split CHILL RINGS and SAVE MONEY



Patent No. 2,156,169

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Use WEDGE Chill Rings-Thread Protectors

Fatigue Failure Of Aircraft Parts

(*Continued from page* 37)

parts, and is apparently very successful.

A considerable amount of fatigue testing has been done on a number of aircraft parts at the Consolidated Vultee Aircraft Corp., Vultee Field Div. Some preliminary criteria have been established based on the actual fatigue tests of the parts involved compared to the life at the time of failure in service. A number of typical examples will be discussed in this paper. Since no actual flight loading data were available, the magnitude of the loading for these fatigue tests was arbitrarily considered to be at or near the maximum applied load, in order to be conservative in the estimate of the stress range. Parts were then tested by repeated loadings to a load of the aforementioned magnitude, until a failure which duplicated the failure in service was produced. The number of loadings required to produce failure was then correlated with the life of the part in service on the airplane. Further tests made on an improved design of the part involved were then compared to the tests on the original part.

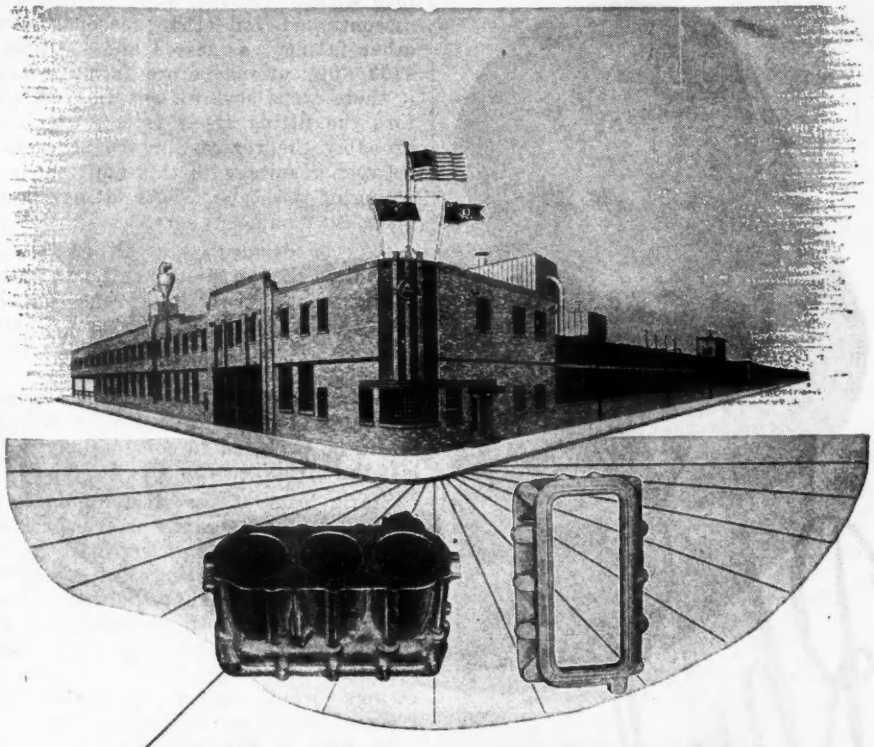
Results of Tests

One of the most interesting series of fatigue tests was made on a steel outer wing attachment fitting of a basic trainer, which had been static-tested previously. The short fatigue life of this particular part was discovered accidentally when it was decided to subject the wing to a combination of weathering and repeated loading tests in order to test the strength of the wood components of the structure. The fitting itself failed in this test after 131 applications of 67 per cent of design load, which corresponds to full applied load. Other fittings tested failed at between 175 to 200 applications of load. A typical failure is shown in Fig. 2. This was considered to be very serious, and the part was immediately strengthened. This redesigned part withstood an average of 2500 to 3500 load applications, which was considered to be sufficient.

Along about that time, reports were received from the field indicating failures of this part in service. The parts failed after from 150 to 500 hr of flight, the average being slightly over 300 hr. Fig. 3 shows a part which failed in service. It is easy to see that this failure is identical with the laboratory failures.

In the meantime, an aluminum alloy fitting of a different design for the same airplane was also tested. This had been previously fatigue-tested in conjunction with a test of a magnesium-skin outer wing panel. This part withstood 7279 applications of

(*Turn to page* 68, *please*)



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load without failure, when the test was discontinued for other reasons. Another fitting was tested and withstood 4763 applications before failure. With it there were several bolt failures before the fitting itself failed, which is probably the reason for the difference between results with this and the first fitting of this type. These fittings have given no trouble in service.

It was decided that although the "rework" of the first mentioned steel fitting was a great improvement over the original, an investigation should be made of a possible redesign. The redesign is shown in Fig. 4 after it had carried 11,650 applications of load before failure. A fitting of this type would be expected to considerably outlast the airplane.

Static tests of the steel fitting had been made, but no part was ever broken under static loading. Even with heat-treated bolts the fitting was stronger than the bolts. From the results of static test, it is safe to assume that this fitting probably could carry 200 per cent of design load. The dural fittings would carry approximately 125 to 150 per cent of design load.

In Fig. 5 the test results given above are plotted on log-log section paper, and the inclinations of the different curves are indicative of the stress concentrations. The slopes of the curves also may be significant with respect to the weights of the parts. A part that will carry 200 per cent design load is likely to be heavier than a part that will carry 125 per cent design load. By correlating the results of these tests with failures that occurred in service, it was established that a loading of this particular part of this particular type of airplane is equivalent to approximately one load application per hour of flight.

A wing-to-fuselage attachment fitting began to fail in service after approximately 2000 hr of flight. The failures indicated that a repeated side load was being applied. In the design it had been assumed that no side load would be carried, but it was discovered that there was such a load, which was due to the shortening under compression of the spar cap to which these fittings were attached. These fittings are approximately 17½ in. from the centerline of the airplane. The compression stress at the spar at design load was 35,400 psi. Taking a load of 60 per cent design load, the elastic compression of this spar cap—

$$e = \frac{SL}{E} = \frac{0.60 \times 35{,}400 \times 17.5}{10{,}300{,}000}$$

$$= 0.036 \text{ in.}$$

These fittings were fatigue-tested under the load which would produce a deflection of 0.036 in., and it required approximately 40,000 reversals of load to duplicate the failure in service. The failure occurred either at the edge of the washer which caused stress concentration, or at the base of the fit-

(*Turn to page 72, please*)

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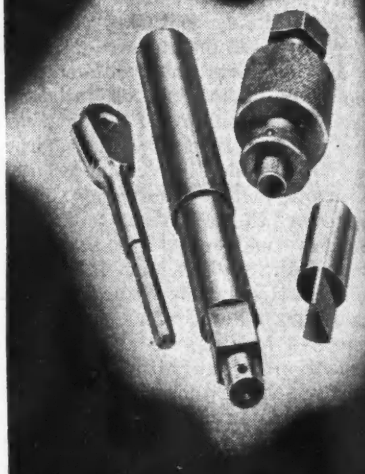

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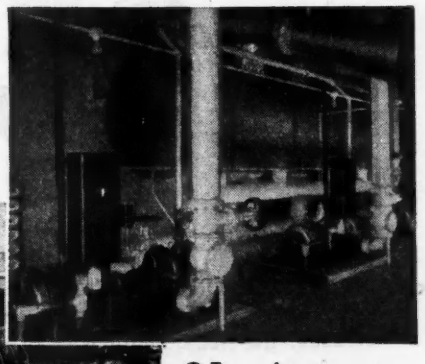
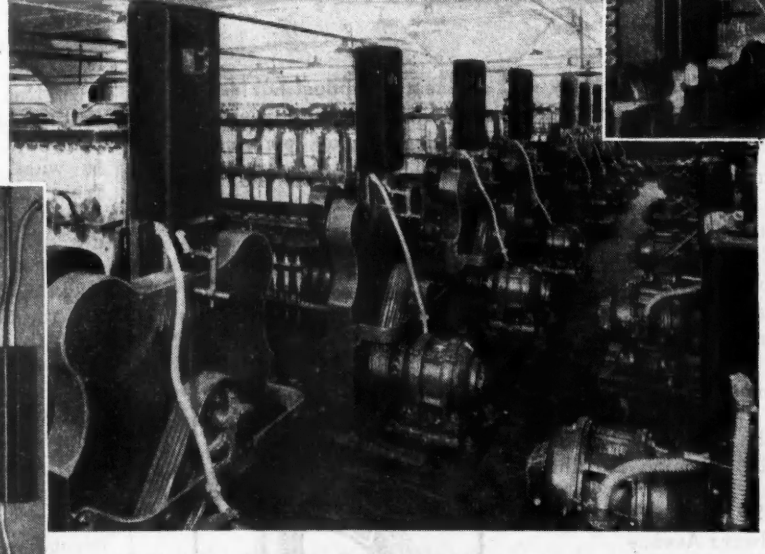
Which Type Do You Need?
If you want short-circuit protection, you can select a starter which has a fusible motor-circuit switch or a breaker to provide such protection. Or, if you do not need short-circuit protection, you can choose a starter which is equipped with a nonfusible motor-circuit switch that serves only as a disconnect. Both types are available in a variety of enclosing cases, as shown on the opposite page.

Co-ordinated for Protection
With G-E combination starters, you're sure that the motor-circuit switch or breaker has the proper rating for the magnetic starter with which it is used. The fuses or breakers provide adequate short-circuit protection to the motor, the starter, and subsequent motor-branch-circuit conductors when connected to a power supply for which they are recommended. The co-ordination of thermal overload relays with the fuses or breakers affords complete motor overcurrent protection under any condition of operation.

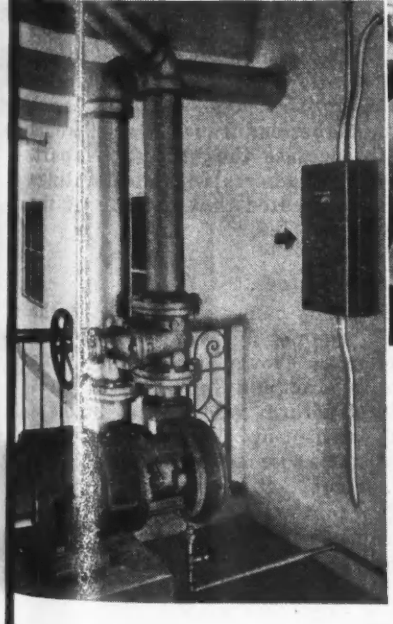
Increased Safety
By placing the motor-circuit switch in the same case with the magnetic starter, the switch can be mechanically interlocked with the cover, so that the cover cannot be opened while there is power on the starter. This is an important advantage because, when a separately mounted switch and starter are used, there is nothing to prevent the operator from opening the case while the starter is "hot."



G-E combination starters can be mounted on or near the machine even in damp locations, such as this pump-room installation.



This combination starter controls a ball-bearing splash-proof motor direct-connected to a centrifugal mash pump in a brewing plant.



Combination starters and shipper-rod switches are used to control the operation of each frame operated by this spinning-frame drive.

WANT MORE DATA? More complete information on G-E combination starters will be found in Bulletin GEA-3715. Ask our nearest office for a copy or write direct to General Electric Company, Schenectady 5, N. Y.

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ting, which also is a point of stress concentration because of the change of direction of material. After various combinations of thicknesses and diameters of washers had been tried without sufficient improvement over the original design, it was decided to use a thinner material, which would result in less stress for a given deflection. It was also necessary to change to steel, to provide sufficient strength. Although this slightly raised the stress due to bending, because of the higher value of the modulus of elasticity of the material, the fatigue limit of the material was considerably higher. This fitting and the results of some of the earliest and some of the latest tests are shown in Figs. 6 and 7. The number of loadings the new part could withstand was raised to between 100,000 and 160,000 applications.

It is to be noted that a plate was added to act as stiffener for the bottom, to keep it from bending when subjected to tension loads. This seemed to have no effect on the fatigue strength. In this case there appeared to be 20 reversals of load per hour of flight.

Empennage Components

One great source of trouble in all types of aircraft is in the empennage and empennage fittings. On one model, failures began to occur after about 2000 hours of flight. The vertical stabilizer rear spar attachment to the fuselage would crack, starting at a free edge of 0.051 aluminum alloy, and would progress rapidly until complete failure occurred. This failure, if not caught in time, would result in loss of the airplane. Tests were made which duplicated the failure in service. Fig. 8 shows a failure of the part identical to that which occurred in service after approximately 2000 reversals of applied load. This is equivalent to one load application per hour of flight. It was noticed that the sheet buckled at the edge between bolts at the point where the failure occurred. This caused a bending back and forth of the material, giving very high reversals of stress due to the local buckling (see Fig. 9). Tool marks and other nicks and scratches also caused stress concentration. The defect was remedied by adding flanges to stiffen the edge as shown in Fig. 10. On another version of this stabilizer, the fitting was made of 0.072 aluminum alloy sheet instead of 0.051 sheet. At applied load there was no buckling at the edge, and this part withstood 20,000 reversals, which was considered satisfactory.

Similar failures occurred on the horizontal stabilizer. Here again the cause seemed to be a local buckling of an edge of a sheet-metal bracket. In a test there was no failure after 20,000 reversals of applied load. It was then decided to vibrate the surfaces in order to obtain a larger number of reversals at lower load. Tip deflection during vibration was approximately ⅝ in. each side of neutral. This corresponds to approximately 30 per cent of design load. After approximately one million reversals, failure occurred which simulated the failure in service.

In this particular case it was practically impossible to reinforce the fitting and maintain interchangeability. It was therefore decided to change from aluminum alloy to normalized chrome-moly steel, retaining the same design. It was figured that the higher modulus of elasticity would delay buckling at the edge of the material, and the higher endurance of steel would tend to increase the life of the part. A test of stabilizers with steel fittings installed indicated that the life of the part was doubled.

Control System

A frequent cause of trouble in the control system is failure of pulley brackets, as shown in Fig. 11. This occurs in practically any type of sheet metal structure where the load is taken on bent-up flanges. Although statically these may be very satisfactory, the constant reversals of load, in addition to the effect of cable vibration, cause fatigue failures of the type shown. The cure for this is simple:

(*Turn to page 74, please*)

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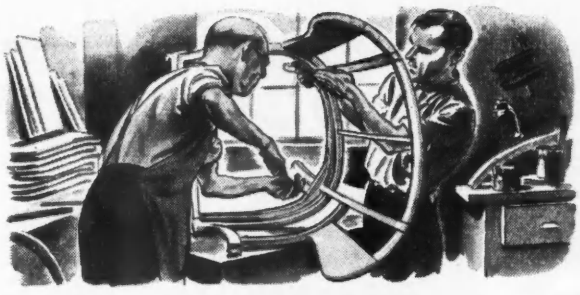

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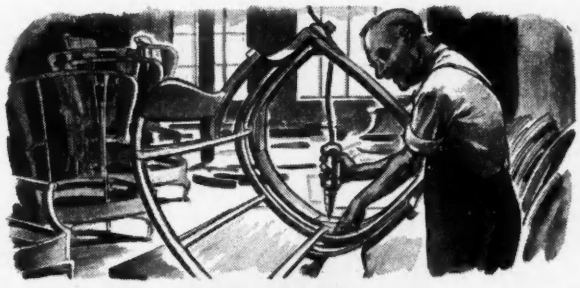

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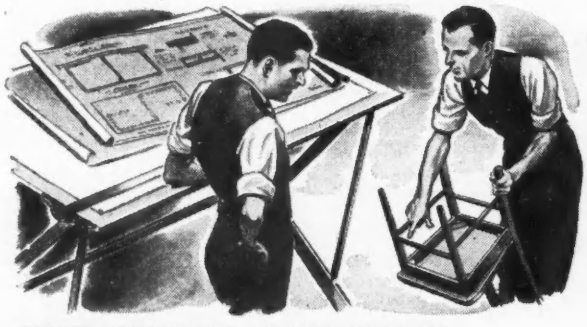

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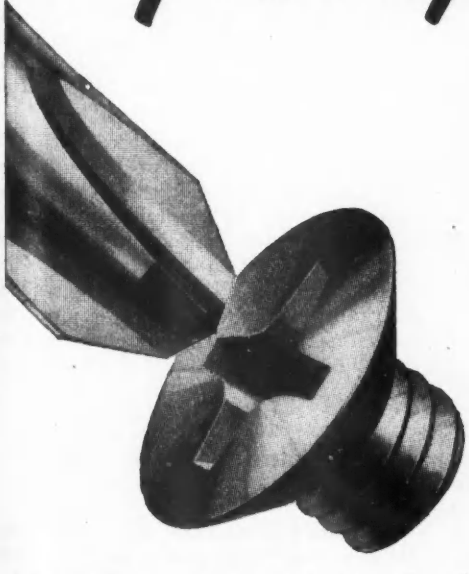

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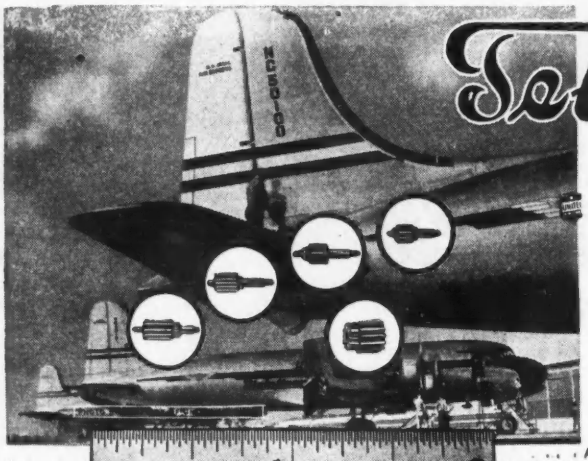

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When filler strips are added the load is put more directly into the web of the fitting, and bending of the flanges is reduced.

Landing Gear

Another fitting on the trainer which showed evidence of failures from repeated loadings is the fitting attaching the landing gear to the wing. Cracks were noticed at the lower attachment bolts after an average of about 1000 hr of flying time. If these cracks traveled to the bolt hole, no further damage occurred, but if they passed around the bolt head, following the edge of the spot face, an accident might result. Tests were made by repeated loading, both for the three-point landing and level landing loading conditions, but the failure could not be duplicated within a reasonable number of load applications. On one set of fittings, 25,835 applications of load were made, varying from 67 to 80 per cent of design load, and it seemed the damage was caused by vibration. The parts were then tested by applying stress reversals of about 90 per cent of applied load in the fore and aft, or drag, direction. A typical failure occurred after about 45,000 applications. This failure apparently was caused by a concentration of stresses inherent in the design. The cure for this also was simple. As no further damage ever occurred when the crack led into the bolt hole, it was decided to add a sawcut in this location, which would cause the stresses to be relieved. A part reworked in this manner was then tested and did not fail until after 176,600 reversals of load. Fig. 12 shows a specimen with the sawcut to the bolt hole, and also the location of the crack, which developed in a fatigue test after 176,600 load reversals. A similar specimen without the sawcut failed after 45,000 load reversals.

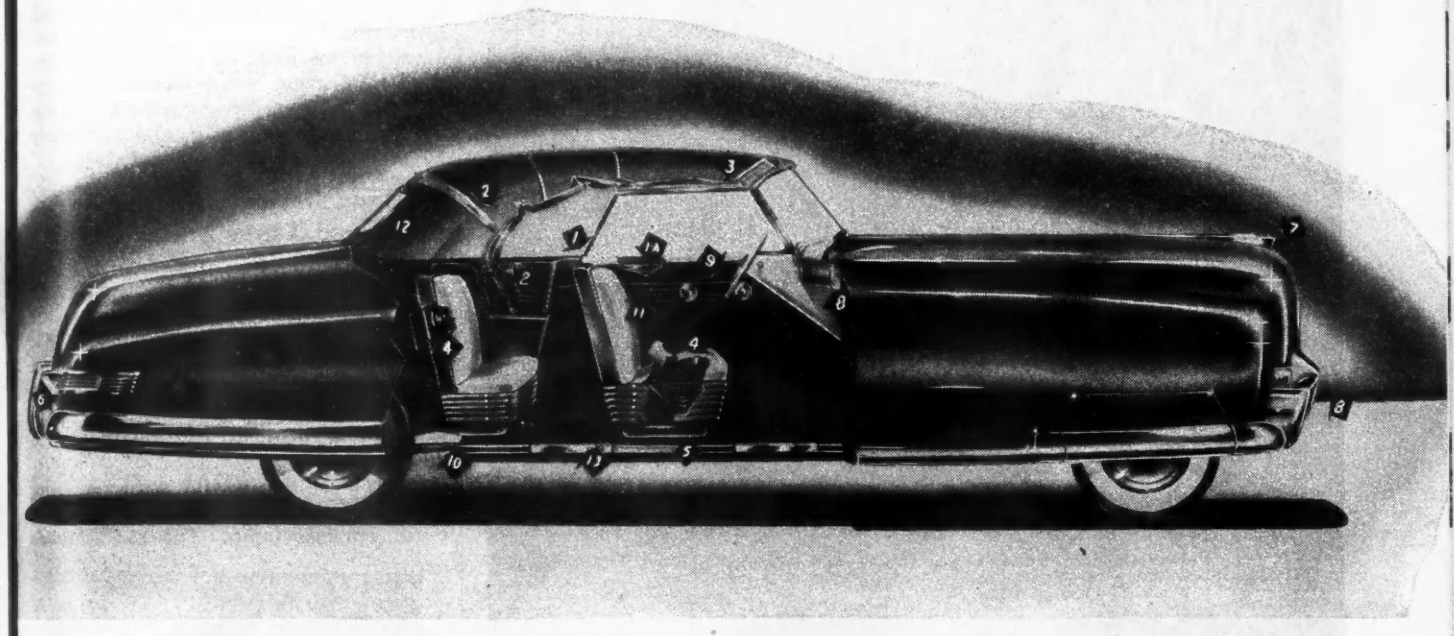
It has been estimated that with this type of airplane, four or five landings are made per hour of flight. This would correspond to approximately ten load reversals of the magnitude of the test per landing, based on the test of the original part. This figure agrees remarkably well with results obtained by actual stress readings during landing of a medium bomber and a large transport.

Poulsen and Narden, Inc., Sold to S. Eisenrod

Poulsen and Nardon, Inc., one of the largest machine shops in Southern California has been sold to E. Eisenrod, president of the Lincoln Machine Co., Providence, R. I., for an estimated $1,000,000. Billings of Poulsen and Nardon last year approximated $7,000,000. The plant will continue under the direction of C. J. Nardon as general manager. Eisenrod will head the company as president.

."wrought with greatest care each minute and unseen part"...

Longfellow's words clearly illustrate the manufacturing precision developed by F. L. Jacobs Co. in the making of automotive parts.



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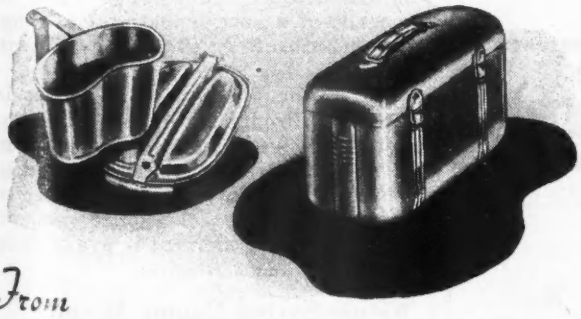
4. CUSHION SPRING AND BACK ASSEMBLIES
5. SEAT SLIDES
6. TAIL LIGHT ASSEMBLIES
7. HOOD ORNAMENTS
8. INSTRUMENT PANELS • ASH TRAYS • GLOVE BOX DOORS • FRONT GRILLES
9. HORN BUTTON RINGS HARDWARE
10. SPRING COVERS
11. DECORATIVE DOOR PANEL MOLDINGS
12. BACK LIGHT FRAMES
13. DOOR SILL SCUFF PLATES



From

MESS KITS *To* DINNER PAILS

The eyes of all America are turned upon American industry . . . looking to it for the solution for post-war employment . . . Speedy change-over from war production, when "V-Day" arrives, will mean jobs for returning veterans and continuing jobs for today's war workers.

Parts, both large and small, seen and unseen, such as those shown in the cut-away illustration above were made for the automotive industry before the war and, with many more, will again be made for the same industry when peace-time production is again resumed. They will be made with the added developments gained from our valued wartime experiences in precision production techniques.

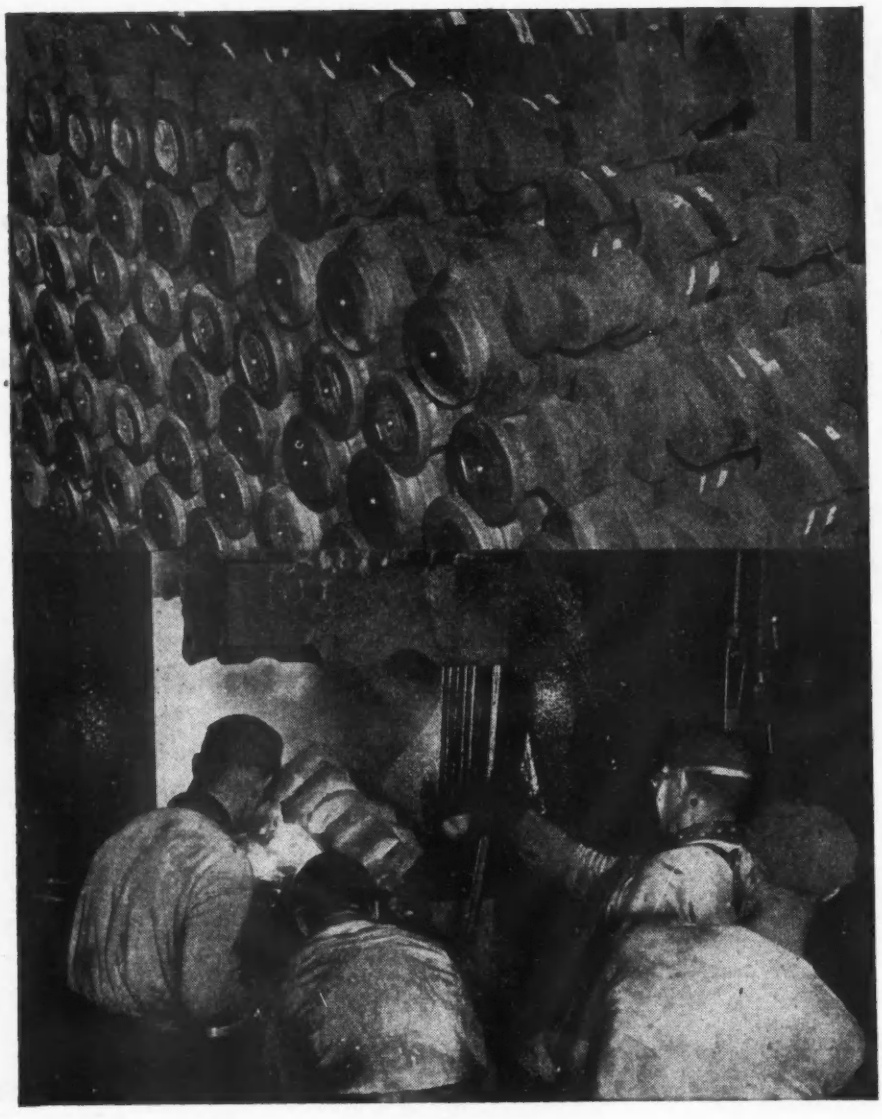
Though we are one hundred percent on war production, our Planning and Engineering Departments are in position to discuss with you your plans for post-war mass production.

F. L. JACOBS CO.

MAIN PLANT
1043 SPRUCE STREET, DETROIT 1, MICHIGAN

DIVISIONS:
DALLAS PLANT, Detroit, Michigan
GRAND RAPIDS METALCRAFT DIVISION, Grand Rapids, Michigan
SUSPENSION PLANT—LONYO BLVD., Dearborn, Michigan

SUBSIDIARIES:
PARTS MANUFACTURING CO., Traverse City, Michigan
CONTINENTAL DIE CASTING CORP., Detroit, Michigan



CRANKSHAFTS by the hundred thousands are forged under strict laboratory control by WYMAN-GORDON . . . all types . . . all sizes.

WYMAN-GORDON
WORCESTER • MASSACHUSETTS
HARVEY, ILLINOIS DETROIT, MICHIGAN

DANLY DIE SPRINGS

MEDIUM PRESSURE HIGH DEFLECTION
HIGH PRESSURE MEDIUM DEFLECTION

DANLY MACHINE SPECIALTIES, INC.
2100 South 52nd Avenue • Chicago 50, Illinois

Milwaukee..111 E. Wisconsin
Detroit...1549 Temple Ave.
Cleveland..1550 E. 33rd St.
Dayton....990 E. Monument
Rochester..16 Commercial St.
Philadelphia.3858 Pulaski Av.
Long Island City 47-28 37th St.
Ducommun Metals & Supply
4890 S. Alameda, Los Angeles

Be 100% With 10% Buy War Bonds

New Products for Aircraft

(*Continued from page* 42)

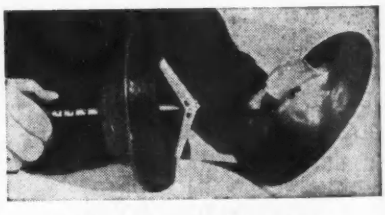
"joy" stick in pursuit aircraft. Through electronic amplification and the servo motors of the control surfaces, the stick moves the airplane in the same direction, and in the same proportion as the stick itself is moved. A stabilizing mechanism gives the stick "feel" which prevents the inadvertent application of abrupt control.

The formation stick is manufactured also by Jack & Heintz, Inc., Cleveland, Ohio. With the aid of production line assembly methods and specially developed production tests, outstanding production has been accomplished, and deliveries are said to be approximately 40 per cent ahead of schedule.

Patching Device Seals Punctured Tanks

A bullet-hole patching device which seals a tank punctured by gunfire in less than 30 sec was disclosed by the United States Rubber Company. It will plug holes ranging in size from ½ to 4 in. in diameter and is effective against damage by small arms ammunition and also larger shells up to 20 mm.

The device consists of a rubber ring of spongy synthetic rubber and a patented spring clamp. The soft rubber



Bullet hole patching device

will deflect to any shape and will work on cylindrical or irregular surfaces. It is made of a special material to resist the deteriorating effects of oil and gasoline.

To install, one end of the clamp is inserted through the hole and two metal fingers open up to grip the inside of the tank, drawing the patch tight to the outside. The patch usually serves as a temporary seal and is removed when welding equipment is available to make permanent repairs.

Weight-Saving Engine Mount

An engine mount for B-29 Superfortresses which saves 36 lb per airplane is announced by The Goodyear Tire & Rubber Co. The saving per mount, over types of B-29 engine mounts currently in use, is almost 1½ lb. Each of the B-29's four engines requires six mounts.

This new device features a cylindrical cushion of rubber which operates in conjunction with a self-lubricated ball joint. The combination results in the control of vibratory forces in all directions.

equipment up to par

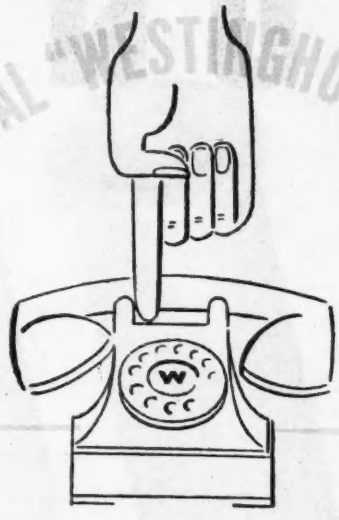
· TO MAINTAIN MAXIMUM PRODUCTION

HERE'S A *3-way service* TO MEET EVERY MAINTENANCE NEED

Why take chances with overworked electrical equipment in your plant? Case after case has proved that failure to inspect, repair or recondition equipment in time results in costly shutdowns that slow down production.

Here's an example: A 25-year-old transformer bank, protected by a faulty circuit breaker which had not been inspected at regular intervals, was blown out by a short circuit in a synchronous condenser. The entire plant had to be shut down for six days while temporary transformers were installed—and again weeks later when new equipment was finally obtained.

Don't let costly failures like this occur in your plant. Knock out electrical troubles before they start . . . with preventive maintenance. Located near you, ready to serve you, are Westinghouse District Manufacturing and Repair Plants, Renewal Parts Warehouses and District Engineering and Service. For full information, call your nearest Westinghouse District office. Westinghouse Electric & Mfg. Company, P. O. Box 868, Pittsburgh 30, Pa.



A NATIONWIDE ELECTRICAL MAINTENANCE SERVICE... AS CLOSE AS YOUR TELEPHONE

Westinghouse has experienced engineers, factory-trained repairmen, complete plant facilities, special machines and testing equipment, plus genuine Westinghouse Renewal Parts . . . all available for your electrical and steam repairs and maintenance.

For prompt service just phone your nearest Westinghouse office and ask for "Maintenance".

KEEP YOUR ELECTRICAL EQUIPMENT UP TO PAR WITH . . .

Westinghouse

Maintenance Service

REPAIRS • PARTS • ENGINEERING

New Products

(*Continued from page* 40)

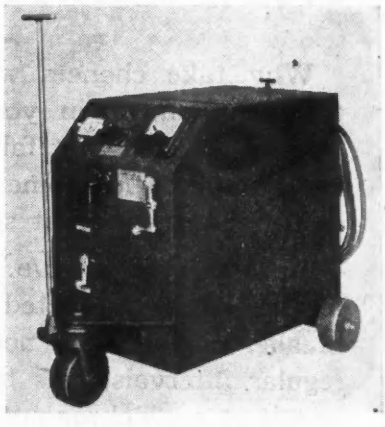
precision thread and form grinders made by The Sheffield Corporation of Dayton, Ohio, has been developed by that company. It is available in two styles, either of which can be applied to new Sheffield machines or to those now in use.

With Model A, the operator presses a button after the crusher roll has been manually lowered into contact with the grinding wheel which is made to revolve. The coolant flow is directed over the crusher roll at the same time it is power fed into the wheel at a constant rate until the feed indicator dial on the crushing device shows that the desired depth of dressing has been reached. The operator then releases pressure on the push-button, thus stopping the wheel, crusher in-feed, and flow of coolant. He lifts the crusher out of wheel engagement and the grinding of the work continues.

Model B is semi-automatic and is distinguished from Model A in that the feed dial indicator is preset for a desired depth of automatic in-feed of the crusher roll. After removal of the wheel guard and lowering of the crusher roll in contact with the wheel, the closing of an electric switch starts the cycle of coolant flow, crushing wheel speed, and feed of the crusher into the wheel. The automatic cycle continues until the desired depth of in-feed is reached, at which point the coolant, in-feed of crusher, and rotation of grinding wheel are automatically stopped. The operator then manually returns the crusher roll to upper position and continues with grinding of the work.

Portable Test Set

A portable a-c test set, mounted on a three-wheeled truck so it can be easily moved about and plugged into any 115- or 230-volt, 60-cycle outlet, and capable of supplying smooth stepless test voltages from 0 to 15,000 volts, is now in production at the General Electric Company, Schenectady, N. Y. Though relatively small—only 36 in. high, 49 in. long, and 30 in. wide—the set has a capacity of 5,000 volt-amperes and can be used for highly accurate testing of generators or large motors of approximately 1,500 hp, transformers up to several thousand kva, short lengths of power cable, also insulators and other pole line hardware.

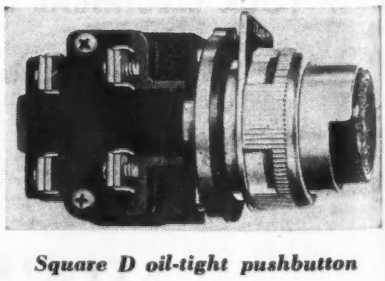


G-E 5 KVA test set

Oil-Tight Pushbuttons

The Square D Company, Milwaukee, Wis., has just introduced its line of Class 9001 Type T oil-tight pushbuttons, designed primarily for group mounting on machinery or control enclosures. While oil-tightness is the

(*Turn to page* 82, *please*)



Square D oil-tight pushbutton

BRAKE DRUMS

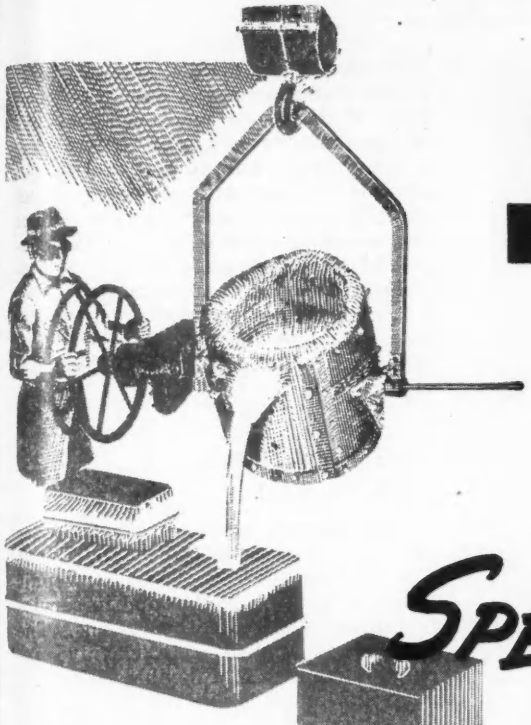
BRAKE SHOES

DEPENDABLE CASTINGS ENGINEERED TO YOUR NEEDS

In addition to making castings in ALL ferrous metals —gray iron, Gunite, malleable, and steel—we have an engineering and metallurgical staff thoroughly familiar with performance requirements. Our customers are invited to take advantage of our broad experience, based on 90 years in the foundry business, to help in selecting the correct material specifications for attaining better-than-expected results. We show here items of particular interest to automotive manufacturers — Cylinder Liners, Brake Shoes, and Brake Drums. Drums are completely finished in our own machine shop. *Let us quote on your requirements.*

MADE BY
GUNITE FOUNDRIES
ROCKFORD, ILLINOIS

GUNITE CASTINGS...FOR TRUCKS, TRACTORS, TRAILERS, and BUSES



JESSOP

CAST-TO-SHAPE TOOL STEELS

SPEED WAR PRODUCTION!

Dies made from Jessop Cast-to-Shape Tool Steels, used for many stamping and forming operations, have helped speed vital equipment to the fighting forces.

Time is saved because the die is cast to the shape in which it will be run and is furnished in a fully annealed condition to facilitate finish machining.

Material is saved because of the small amount of surface (usually ⅛") that has to be removed.

Costs are materially reduced because of these savings.

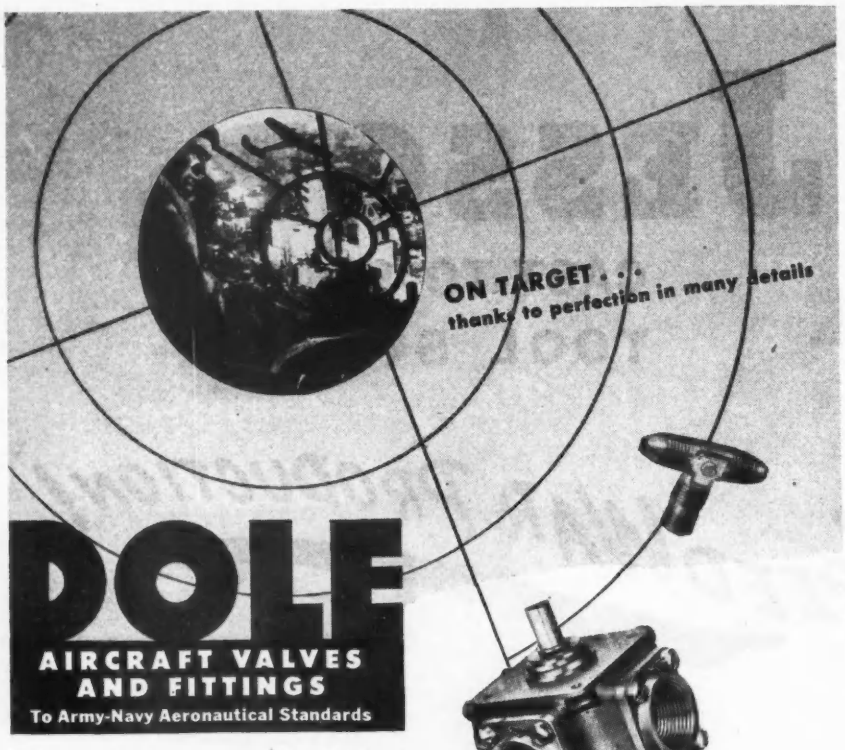
Cast-to-Shape Ring Dies in a large range of sizes are carried in warehouse stocks. Write for booklet "Jessop Cast-to-Shape Tool Steels." No obligation.

also Manufacturers of:

HIGH SPEED, ALLOY AND CARBON TOOL STEELS • CARBIDE-TIPPED TOOLS AND DIES • CAST CUTTING ALLOY • PRECISION GAUGE • MUSIC WIRE • DRILL ROD • CHISEL STEELS • COMPOSITE TOOL STEELS • STAINLESS STEELS • STAINLESS-CLAD STEELS

JESSOP STEEL COMPANY

MAIN OFFICE AND WORKS: WASHINGTON, PENNA.



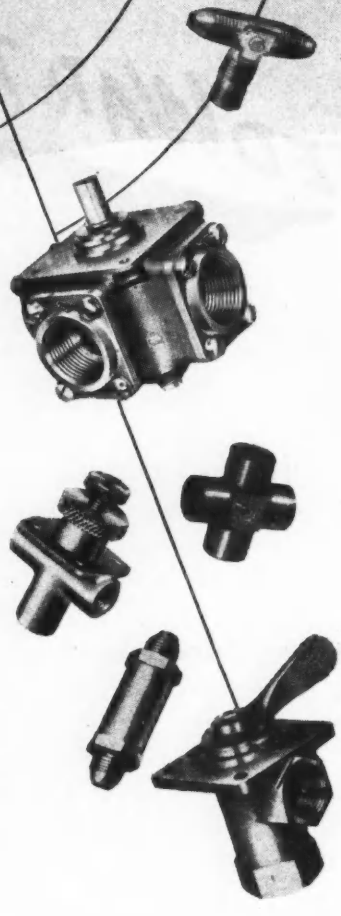
DOLE

AIRCRAFT VALVES AND FITTINGS

To Army-Navy Aeronautical Standards

Many designers and skilled workmen have collaborated toward the result when a U. S. warplane comes "on target." The Dole Valve Company's contribution is an honest precision—an extreme care—because we know that the smallest error by any one participant can offset all the care of the rest.

Such has been the war-winning teamwork of American manufacturers. The increased skill we have gained will serve this and other industries for years to come.



THE DOLE VALVE COMPANY · Established 1906 · 1901-1941 Carroll Ave., Chicago 12, Ill.
LOS ANGELES · DETROIT · PHILADELPHIA

principal feature of this new line, there are several other advantages. The new Type T units are more compact and can be mounted on closer centers than previous types, and all terminal screws can be reached with a screw driver without going in at an angle. Since the operating mechanism and the contact block are separate units, it is possible to obtain a combination to cover a wide range of circuit requirements with a limited stock of three types of operators and four types of contact blocks.

Plastic Base Filler Replaces Solder

"Econite," a resinous plastic base filler, has been developed by the Evans Chemical Co., Detroit, Mich., for repair filling jobs in production and in service to replace lead solder operations. The material is applied on a cleanly prepared surface with a flexible glazing or putty knife and is finished off by filing or sanding. It is air-drying and is said to retain its adhesion indefinitely. It is claimed that razor sharp feather edges are easily obtained. It will take surface finishes of either lacquer or synthetic top coat of air-drying or baking type.

Casting Sealants

Monsanto Chemical Company, St. Louis, Mo., has placed in production a new series of casting sealants which frees the United States from dependency on foreign-produced tung oil for impregnation of aluminum and magnesium airplane parts.

Finely-machined untreated castings made from aluminum or magnesium show a pronounced tendency to develop porosity. This does not affect their mechanical strength, nor does it alter their status of utmost essentiality to aircraft manufacture. The porosity, however, results in leakage of liquids and vapors in lubricating, cooling and hydraulic systems.

The sealants are said to make a complete, three-dimensional permeation of

(*Turn to page* 85, *please*)

B·H

Manufacturers of
Sheet Metal and Tubular Accessories
for Leading Engine and
Propeller Manufacturers

B-H AIRCRAFT CO., Inc. 27-01 Bridge Plaza, N., Long Island City, N. Y.

MILLHOLLAND

Automatic DRILLING - BORING MILLING - TAPPING Units

½ to 20 HORSEPOWER DRIVE

AUTOMATIC and SEMI-AUTOMATIC PRODUCTION MACHINERY

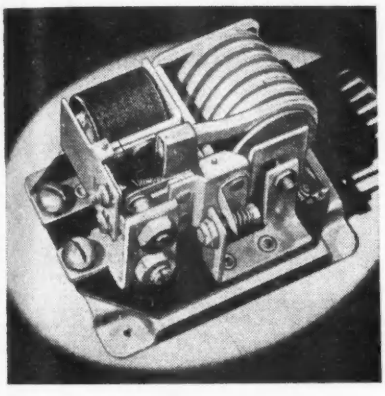
W. K. MILLHOLLAND MACHINERY CO.
Indianapolis, Ind.

the castings, filling the millions of microscopic hollows which they contain without changing their appearance or affecting precision tolerances. After being impregnated, the castings are heat-treated to change the impregnant from a liquid to rubbery solid form.

Reverse Current Relay

Originally designed for special use on auxiliary engine-driven power generators in Army tanks and airplane bombers, the Type 9100 reverse current relay, manufactured by R-B-M Manufacturing Company, Logansport, Ind., is said to be equally effective for any low voltage d-c application.

This relay is said to assure dependable operation on either stationary or mobile equipment. The design incorporates a magnetic latch which prevents



R-B-M Type 9100 reverse current relay

accidental closing of armature and contacts due to vibration up to 10G, or heavy shock. Contacts are rated 100 amp. at 30 volts direct current, maximum.

This R-B-M reverse current relay, without magnetic latch (Type 9000), is also available for use where severe vibration and shock are not encountered —in sizes as low as 300 watts at 6, 12, 18, and 24 volts, direct current.

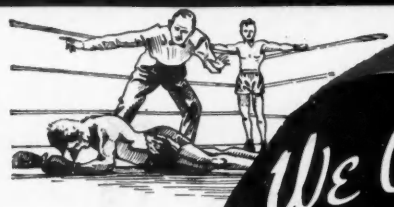
Craze-Resistant Adhesive

A craze-resistant urea-formaldehyde resin adhesive named Urac 183, for bonding intricate wooden parts where the application of high pressure to secure a uniformly thin, durable glue line has heretofore been difficult, is being offered by the American Cyanamid Company, New York, N. Y. The new adhesive, having improved features for low-pressure wood assembly work in the aircraft, automobile, marine and woodworking industries, is said to reduce the problem of crazing or fine cracking of the glue which causes deterioration of the glue lines.

Koroseal Masking Tape

A new Koroseal tape for masking purposes in the plating industry is now being delivered by The B. F. Goodrich Company, Akron, Ohio. It is known as

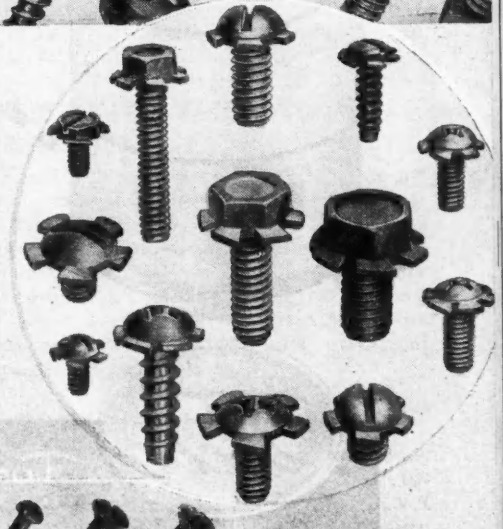
(*Turn to page* 86, *please*)

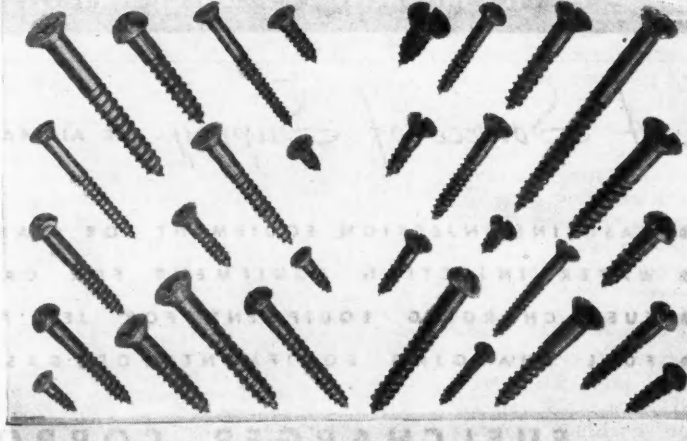


We Can Lick Your Fastening Problems!

Yes, our Engineering and Laboratory Staffs can lick your fastening problems as efficiently and economically as they've licked thousands of others.

Let us know your present difficulties. We'll thoroughly analyze them and recommend fastenings with the correct, scientifically determined design, material heat treatment, temper and finish. Our technicians will also be glad to study the fastening requirements in your post-war products plans, and recommend time-saving, cost-reducing methods that will add strength and endurance to the fastened parts.





At Top: SPECIAL fastenings and parts selected from thousands we continually produce to order.

In Circle: "Lock-Tite" screws. The lock washer is part of the screw.

At Bottom: "Thread-forming" Sheet Metal Screws eliminate tapping by cutting perfect mating threads in the material.

CONTINENTAL SCREW CO. New Bedford, Mass., U.S.A.

We don't want anyone to get the idea that Turner Gauges can be used only to speed up the manufacture of shells and other instruments of war. Yes, it's true, Turner Gauges are mighty important tools when you're thinking of winning a war, but when you start talking about washing machines and refrigerators and salesmen on every doorstep . . . well . . . Turner Gauges can help you. They'll speed up your production processes and guarantee a finer finished product. Write us. We've got good news for you.

TURNER BROTHERS

TURNER GAUGE GRINDING COMPANY
2622 HILTON ROAD • • FERNDALE 20 MICHIGAN

Koroseal Tape MX, and is an adjunct to Koroseal Tape RX and Korolac RX, a solution of Koroseal, used in the plating industry.

The new masking tape can be used for practically all kinds of plating solutions, including chromic, alkali and acid dips, the company says. Any item which can be covered with regular friction tape can be masked by the new product. To distinguish it from Koroseal Tape RX, which is made in glossy black, the new Koroseal Tape MX is gray.

Automatic Machine Speeds Parts Washing

An automatic washer for industry has recently been put on the market by the Modern Mechanic Company, Chicago, Ill. The heavy-duty model above includes rinse vats for production-line work. One man can operate three baskets of metal parts, washing, rinsing and draining each basket at the same time.

Modern Mechanic automatic washer

The Modern Mechanic's impeller pump is powered with a ½-hp single phase motor and forces a ton of solvent every minute over parts to be washed, removing acid, grime, grease, etc. Only 65 gallons of washing liquid

(*Turn to page* 90, *please*)

A Source of Supply FOR AIRCRAFT ENGINE MANUFACTURERS

- GASOLINE INJECTION EQUIPMENT FOR SPARK IGNITION ENGINES.
- WATER INJECTION EQUIPMENT FOR CARBURETED ENGINES.
- FUEL CHARGING EQUIPMENT FOR JET PROPULSION ENGINES.
- FUEL CHARGING EQUIPMENT FOR GAS TURBINE ENGINES.

FUELCHARGER CORPORATION

8800 GRINNELL AVE. DETROIT 13, MICH.

INJECTORS • NOZZLES • MIXTURE CONTROLS • TUBING HARNESS

about ?

You know that the required factor in the above problem, without which it CANNOT add up to a solution, is *increased efficiency in production.* If you apply to this challenge everything you have learned from your war experience plus *everything you can learn from the experience of others* it will still be a battle.

Federal is prepared to make available to you a wealth of information on the application of resistance welding in all of its phase to *better and faster production* (and don't say this cannot apply to your problem until you have the facts). We want to tell you about applications for resistance welding never before believed practical . . . We want to show you new ways to make profitable use of resistance welding equipment you may now have . . . to bring you up to date on the facts about resistance welding as a tool for modern production.

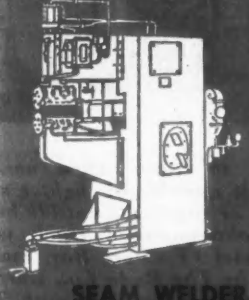
Federal is ready to help, if you will tell us WHAT YOU WANT TO KNOW ABOUT RESISTANCE WELDING.

Write today, stating your problem, bearing always in mind that in resistance welding, *"the name of authority is*

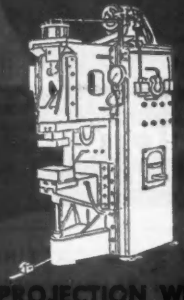
Federal

AND WELDER COMPANY

WARREN, OHIO



SEAM WELDER



PROJECTION WELDER

VERSATILE MODERN PRODUCTION TOOLS

ALUMINUM WELDERS

The limited plastic range of aluminum alloys has always made the welding of these metals an extremely critical problem, has caused many experts to claim that it cannot successfully be done. That it can, has been convincingly proved by the development of resistance welders, both spot and seam welding types, which are now producing aluminum welds of such high quality as to be acceptable for aircraft and other critical parts.

The Federal Machine and Welder Company recently delivered the largest and most modern roll-spot aluminum welder ever built, capable of welding two sheets up to 5/16" thickness . . . has others available, including spot welders capable of welding two aluminum alloy sheets up to .125" gauge at 150 spots per minute.

NEW SMALL SPOT WELDERS

Soon ready for distribution will be several improved models of small spot welders, so versatile in their usefulness and so low in cost that such users as garages, small metal fabricating shops and factory maintenance departments will find them valuable tools. Information on them is available through The Federal Machine and Welder Company.

RESISTANCE WELDING IN MAINTENANCE

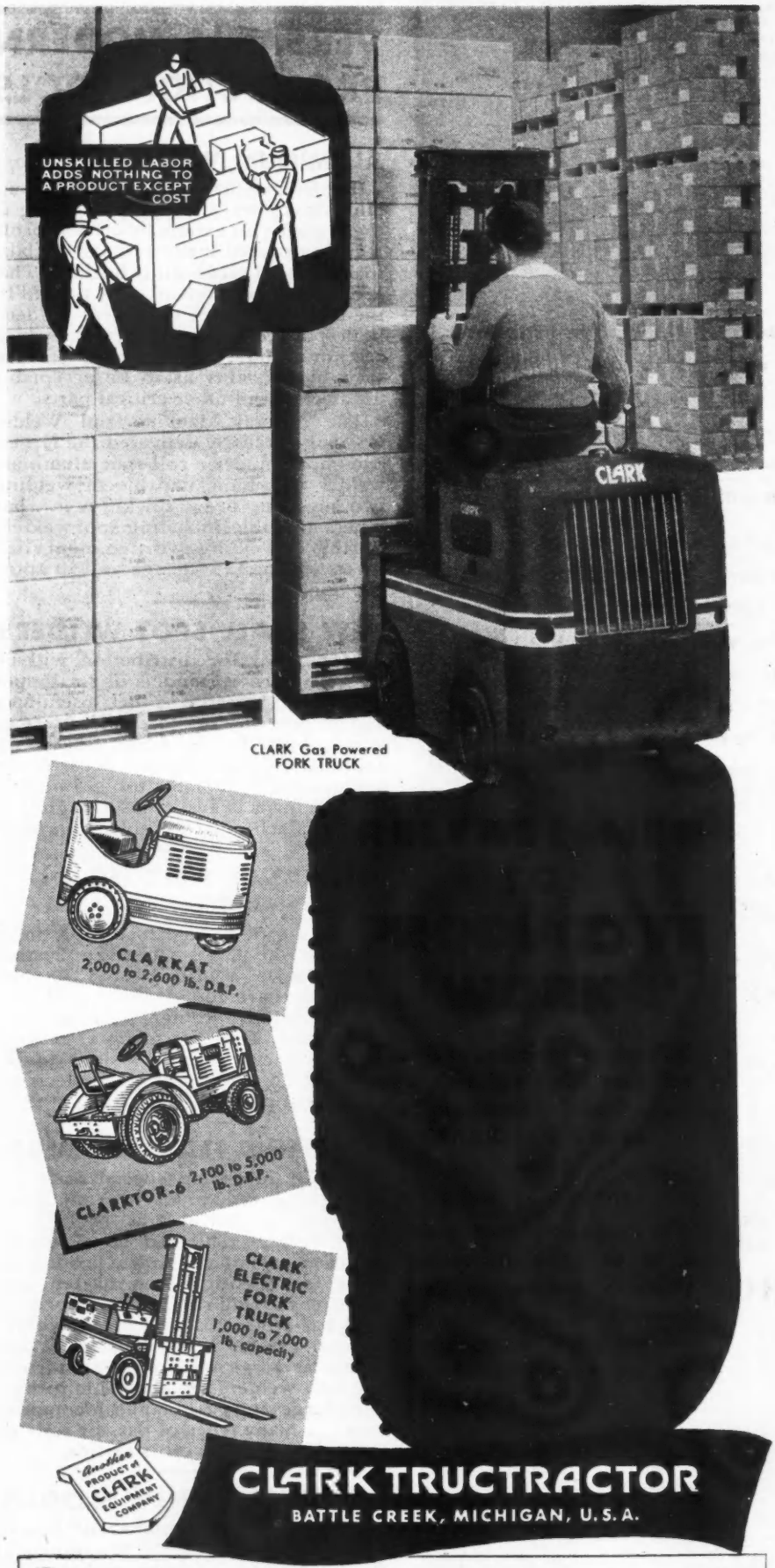
Speaking of maintenance department uses, several plants where application of resistance welding would be least suspected have found small, low cost welders highly profitable for a variety of demands, from repairing or making of sheet metal safety housings to the patching of machine and electrical equipment parts.

2,000 KVA FLASH WELDERS

Among the recent special machines produced by Federal Machine and Welder Company are several 1000 KVA flash welders delivered to a foreign power as part of a complete production plant for making seven to ten foot diameter bearing rings, from hot rolled steel bar stock. Coming up are others of even greater KVA capacity. These particular rings were for tank turrets, but such welders are adaptable to handling large ring gear blanks, locomotive tires . . . many types of bars or rails up to 20 square inches cross section.

OLD TIMER . . . NEW SLOGAN

After several years total absorbtion in war work The Federal Machine and Welder Company, oldest maker of resistance welding equipment, is planning its return to active contact with peace time fields . . . has a new slogan: "In resistance welding, the name of authority is FEDERAL".


UNSKILLED LABOR ADDS NOTHING TO A PRODUCT EXCEPT COST
CLARK
CLARK Gas Powered FORK TRUCK
CLARKAT 2,000 to 2,600 lb. D.B.P.
CLARKTOR-6 2,100 to 5,000 lb. D.B.P.
CLARK ELECTRIC FORK TRUCK 1,000 to 7,000 lb. capacity
Another PRODUCT of CLARK EQUIPMENT COMPANY
CLARK TRUCTRACTOR
BATTLE CREEK, MICHIGAN, U.S.A.

Products of CLARK • TRANSMISSIONS • ELECTRIC STEEL CASTINGS AXLES FOR TRUCKS AND BUSES • AXLE HOUSINGS • BLIND RIVETS INDUSTRIAL TRUCKS AND TRACTORS • HIGH-SPEED DRILLS AND REAMERS METAL SPOKE WHEELS • GEARS AND FORGINGS • RAILWAY TRUCKS

are used and it is automatically screened by baffle-and-grill so it can be used over and over.

Graphitizing Alloy for Cast Iron

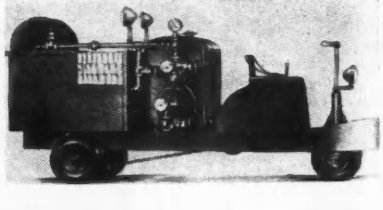
Graphidox No. 4, a product of the Vanadium Corp. of America, New York, N. Y., is a new alloy possessing high graphitizing properties. It is said to give the foundryman a sure method of improving his product and reducing the number of different irons he must melt to meet varying needs. An alloy of silicon, titanium, and calcium, properly balanced to give maximum efficiency, Graphidox No. 4 combines graphitizing value with deoxidation, inoculation for strength, and reduction in chill. The high efficiency of the new alloy so reduces the dosage required that it can be readily and simply added directly to the iron in the ladle, or as otherwise desired.

Construction of Tank Plants Abandoned

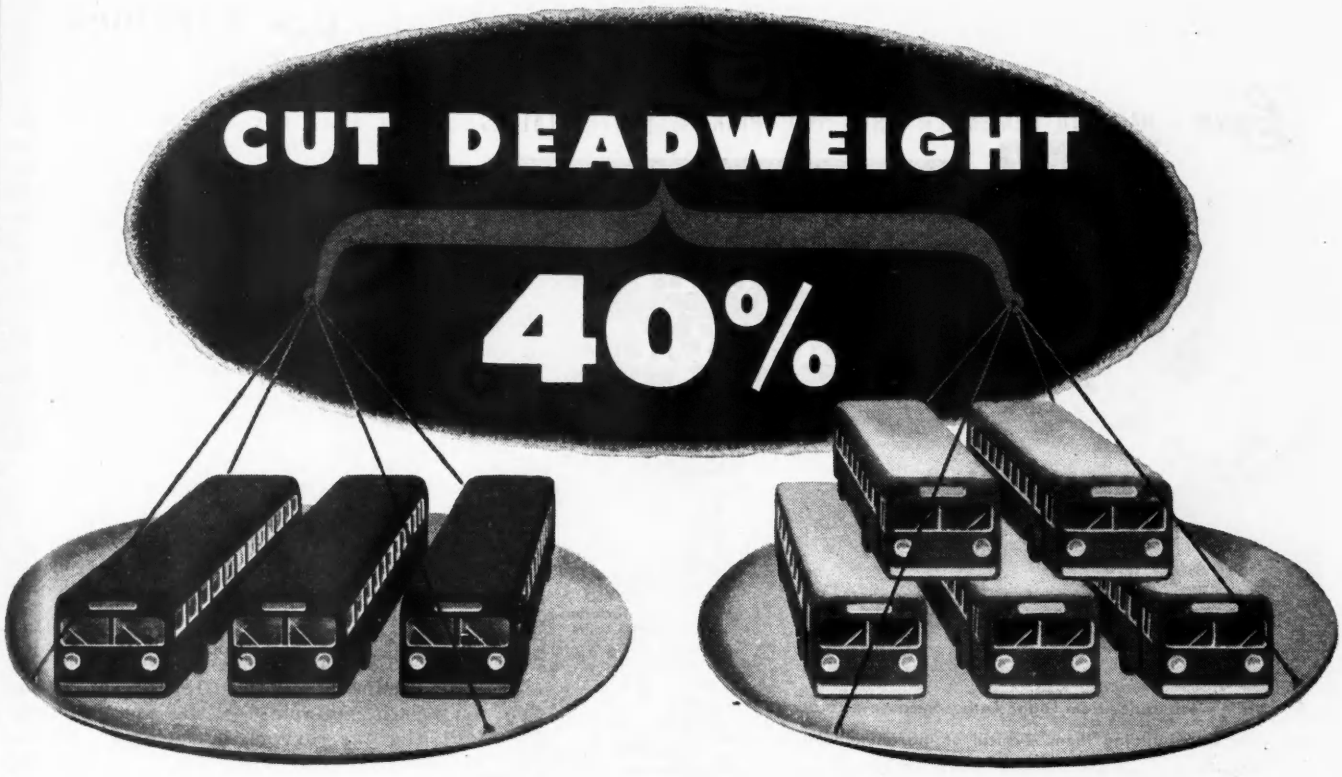
Fitting into the pattern of military cutbacks made possible by the successful prosecution of the war in Europe, the War Department has abandoned the construction of 12 tank plants which could not be completed and reach capacity of production until autumn.

Four of the projected tank plants would have been located in Detroit. They would have been operated by Chrysler Corp., Chrysler subcontractors, Ford Motor Co., and General Motors. Other planned expansions were: American Steel Foundries Cast Armor Plant, East Chicago, Ind.; Ford Motor Co., Dearborn, Mich.; General Motors, Fisher Body Division, Flint, Mich.; Oilgear Co. and subcontractors, Milwaukee; Ordnance Steel Foundry plant, Quad Cities Tank Arsenal (International Harvester) both Bettendorf, Iowa; Waukesha Motor Co., Waukesha, Wis., and Standard Steel Spring Co., Coraopolis, Pa.

Mobile Fire Extinguisher



Designed to travel down narrow aisles, this mobile fire fighter supplements or supplants outside help. The gasoline-powered truck is a Buda Model FF Chore Boy, manufactured by The Buda Co., Harvey, Ill. Maximum speed is 15 mph. The fire-fighting equipment pictured here is furnished by the F. A. B. Manufacturing Co., Oakland, Cal.



with Mayari R*

You can reduce deadweight in busses, trucks and trolleys up to 40 per cent by building with Mayari R, Bethlehem's low-alloy, high-strength steel.

These reductions—with attendant increases in payload—are possible because Mayari R has almost double the yield point of regular structural steel and therefore can be used in lighter sections.

To protect these lighter sections, Mayari R has 5 to 6 times more resistance to atmospheric corrosion than mild carbon steel and 2 to 4 times more than copper-bearing steel. Tests reveal* that it also has high enough endurance limit and resistance to fatigue and impact to withstand the strains and shocks of the toughest road conditions.

Mayari R's high ductility results in quick, easy fabrication under regular shop practices. And Mayari R is readily welded by all the usual methods.

Plan on designing postwar busses, trucks and trolleys with Mayari R. Taking into account weight savings, lower operating costs, longer life, and economical fabrication, you'll find that the advantages of using Mayari R far offset its slightly higher cost.

For complete information on Mayari R, write Bethlehem Steel Company, Bethlehem, Pa., for copy of illustrated booklet on this economical, weight-saving steel.

**Rhymes with "fiery." The "R" is for "Rust Resisting." Mayari, in Cuba, was the source of the original natural alloy-bearing Mayari ore.*

★ ★ ★ BETHLEHEM STEEL ★ ★ ★

Mayari R *makes it lighter... stronger... longer lasting*

Logan A NAME TO REMEMBER WHEN YOU THINK OF BETTER LATHES

The Reason for
LOGAN ACCURACY

No. 850 Manufacturing Turret Lathe

No. 825 Quick Change Gear Cabinet Lathe

Accurate work comes from Logan Lathes because accurate work goes into building them. Typical of maximum tolerances allowed are Bed ways within .0005" of parallelism, and headstock bearing faces held to an accuracy of .0005". To maintain such accuracy in lathe after lathe, one of every seven men building Logan Lathes is an inspector, skilled in the use of precision instruments such as Comparators, Johannson Blocks, Sine Bars, and the most accurate of gauges. Using this precision equipment, Logan inspectors check individual parts, sub-assemblies, and completed machines. They make certain, in short, that every Logan Lathe will work accurately because every part of that lathe fits accurately. This Logan stress on inspection, though costly, is also the wisest economy. Lathes which pass such rigid inspection make friends of the men who use them. Ask your Logan Lathe dealer, or write for full information on all Logan Lathes.

SPECIFICATIONS common to all **Logan Lathes:** Swing over bed, 10½"; Bed width across ways, 6-15/16"; Bed length, 43⅛"; Size of hole through spindle, 25/32"; Spindle nose diameter and threads per inch, 1½"—8; 12 Spindle speeds . . 30 to 1450 r.p.m.; Size of motor . . ⅓ or ½ h.p., 1750 r.p.m.; Preloaded precision ball bearing spindle mounting; Drum type reversing motor switch and cord; Precision ground ways, 2 prismatic "V" ways, 2 flat ways.

LOGAN ENGINEERING CO.
CHICAGO 30, ILLINOIS D-6

Gas Turbines

(Continued from page 20)

It would appear that, for high altitude and high speed, the simple gas turbine-jet combination meets the case; for lower altitudes and speeds, and for large aircraft, the turbine-propeller combination will be used.

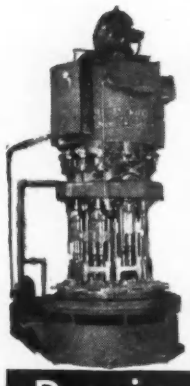
Among points to be considered in the making of a successful turbine engine for aircraft is the fact that turbines consume an enormous amount of air, i.e., in the order of one lb per sec per 50 lb of thrust. It is very necessary, therefore, to avoid entry losses, which seriously affect the efficiency of the engine.

Gas turbines, being virtually "full throttle" engines, are affected seriously by the intake temperature, a fact that must be taken into account in designing to cope with take-off conditions in hot climates as well as in temperate locations.

The gas turbine cannot yet use the chemically-correct 15 to 1 air-fuel ratio suitable for the piston engine; the gas turbine air-fuel ratio is more nearly in the region of 60-70 to 1. The reason for this is that temperatures must be kept lower in the gas turbine than in the piston engine. But development, particularly in materials, will no doubt allow higher temperatures to be employed in due course and, therefore, lower air-fuel ratios, although these ratios will still be higher than those of the piston engine.

The fuel consumption of the simple (Whittle) turbine-jet engine is higher than one lb per lb-thrust per hr, under static conditions; but we are now very close to this figure and may get below it in the near future. The various "staging" arrangements with blowers of the axial and centrifugal varieties will, with propeller or ducted fans (as simple jets), give still lower consumption; and we can foresee consumptions which will be better than full-throttle or take-off figures of the piston engine. In a suitably designed

(*Turn to page 94, please*)



Vertical ROTO-MATICS

Multiple spindle drill heads and automatic clamping provide added production.

Continuous operation is essential for maximum production. VERTICAL ROTO-MATICS are continuous operating, multiple spindle, non-indexing machines that are adaptable to a wide range of machine problems. . . . *Bulletins 110 and 120* may help you solve your problems. Write for them.

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Mfrs. of Machine Tools and Micrometers
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ANY SHAPE • ANY MATERIAL • COMPLETE FACILITIES
Write for Free Forging Data Folder . . . Helpful, Informative
J. H. WILLIAMS & CO., "The Drop-Forging People" BUFFALO 7, N.Y.

There's a Du Pont Molten Salt Bath for Any Type of Case Hardening

Case Depth Desired	Recommended Bath	Temp. °F	NaCN %	STARTING COMPOSITION	REPLENISHING COMPOSITION
0.003" to 0.010"	PLAIN CYANIDE	1400 to 1600	20-30	30 or 45% CYANIDE-CHLORIDE MIXTURE, "CYANEGG" and NaCl, and/or Na_2CO_3	45, 75 or 96% NaCN—depending on dragout loss
0.010" to 0.035"	DU PONT ACCELERATED SALT with Graphite Cover	1500 to 1650	18-22	ACCELERATED SALT or ⅓ HEAT TREATING SALT No. 6 plus ⅔ ACCELERATED SALT	ACCELERATED SALT
0.025" to 0.090"	DU PONT CARBURIZING SALT with Graphite Cover	1650 to 1750	8-12	⅓ CARBURIZING SALT plus ⅔ HEAT TREATING SALT No. 6	CARBURIZING SALT

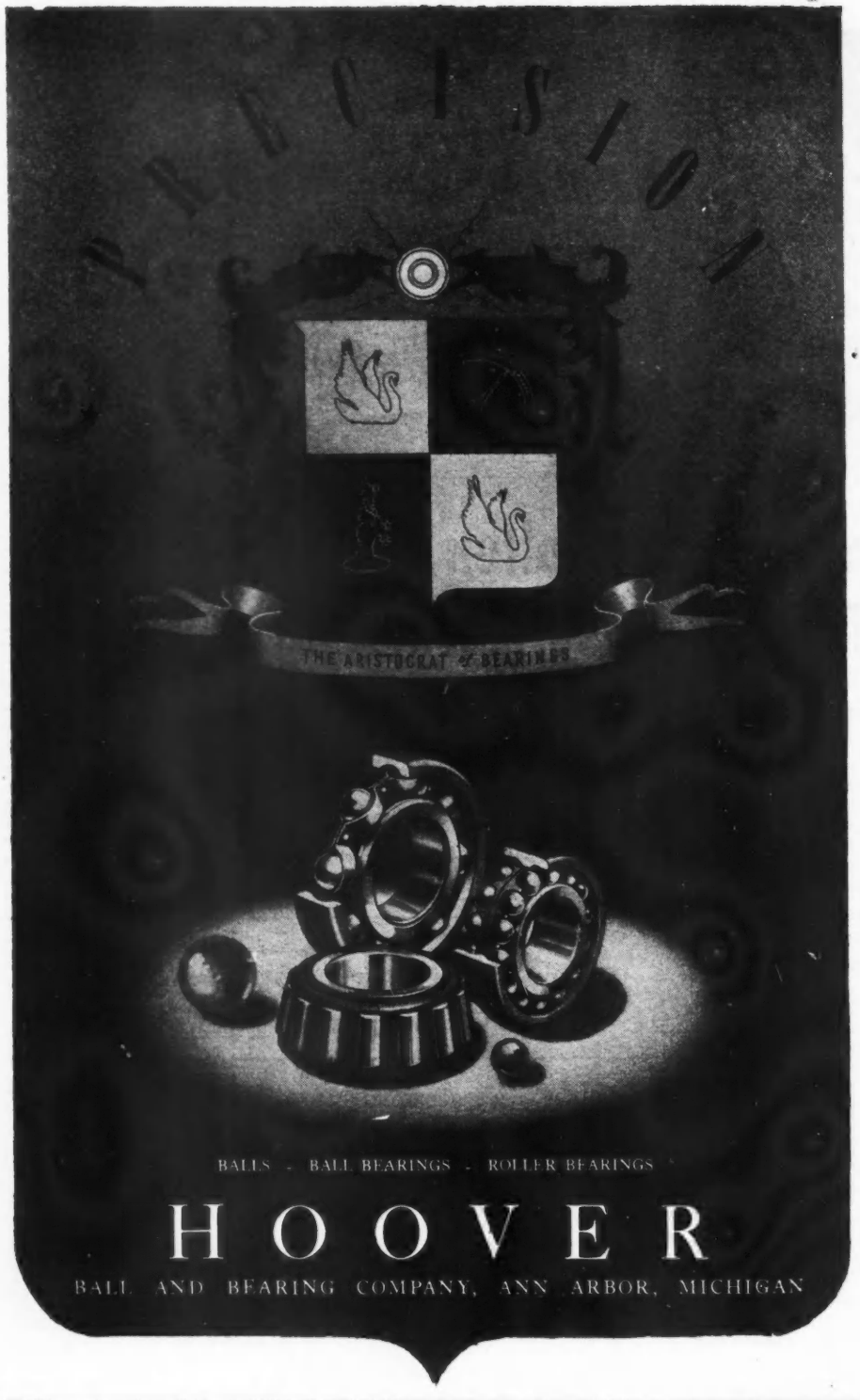
EACH OF THESE BATHS is designed to produce cases of desired depth in the shortest possible time at the lowest possible cost. Yet they're but three of many Du Pont heat treating products that will return top production for you with maximum economy. Du Pont technical men will work with you in selecting the right materials to meet specific needs. For further details write: E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Department, Wilmington 98, Delaware.

SAVE A LIFE—BE A BLOOD DONOR

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

DU PONT CYANIDES and SALTS for Steel Treating


PRECISION
THE ARISTOCRAT of BEARINGS
BALLS - BALL BEARINGS - ROLLER BEARINGS
HOOVER
BALL AND BEARING COMPANY, ANN ARBOR, MICHIGAN

aircraft, this will give better air miles per gallon than the piston engine, provided the airplane is operated under the best conditions for its power plant.

In regard to fuel, the gas turbine generally uses kerosene or vaporizing oil, "any old fuel" will not do, because it may soot and coke the combustion system and impair over-all efficiency. It is essential to have high combustion efficiency in a gas turbine and, because of its large air consumption and relatively-low thermal efficiency, the pressure drop through the combustion system must be kept as low as possible. There must be no "flaming" past the turbine blades, otherwise they will overheat.

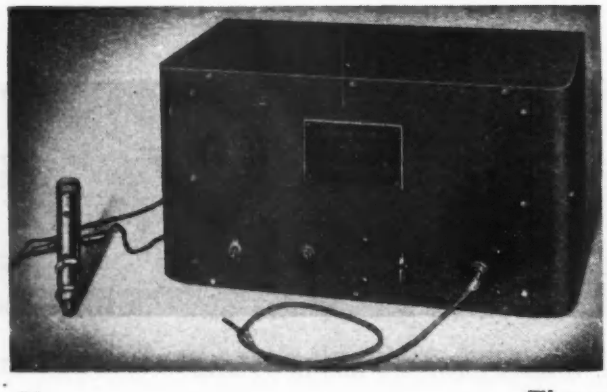
It should not be assumed that gas turbine fuel will necessarily be much cheaper than gasoline. Although turbine fuel may cost about one-half to two-thirds the cost of 100-130 grade gasoline at source, shipping and distribution charges will be the same for both and the ultimate difference on a percentage basis will appreciably be reduced.

In view of the relatively-high fuel consumption of the turbine, there is a strong case for the fuel companies to investigate the possibility of producing a fuel with a very high calorific value per unit volume, because we can more easily deal with weight than bulk in the modern high-speed aircraft.

Although the fuel of the gas turbine is, in relation to gasoline, a "safety" fuel, the safety aspect will be mainly confined to tankage and piping into the aircraft, and not necessarily to the engine. The latter is very like a large blow lamp and, in the event of a crash, will ignite kerosene equally as well as gasoline is ignited by the piston engine.

Air Commodore Banks said the gas turbine would bring us up against compressibility effects in aircraft and this might mean a prolonged period of research. He did not anticipate "buried" engines in aircraft, except possibly in the very largest sizes—200,000 to 250,000 lb gross weight. Wings, he thought, would become thinner and it just did not seem possible to hide the engines completely.

New! PRESSUREGRAPH—Linear Pressure, Time-Curve Indicator



Indicates accurately in linear response, on screen of cathode ray oscillograph, the pressure-time-curve of any internal combustion engine, pump, airline, or other pressure system where pressure measurements are desired. Either static or dynamic pressures.

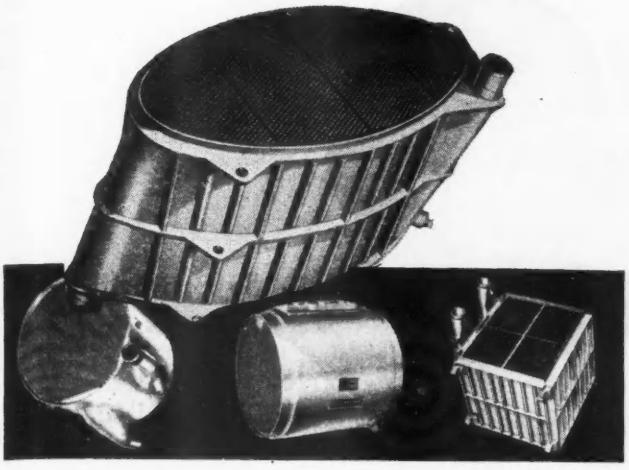
Simple operation—Only one control

In operation the pick-up section (at right) is inserted in cylinder, chamber of airline, etc. The pick-up response is transmitted after amplification, to screen of oscillograph. Successfully applied for pressure-time-curve of C.F.R. aviation fuel test engines, also 2-cycle engines for pressure-time curve of main cylinder or crankcase.

For details address manufacturer

ELECTRO PRODUCTS LABORATORIES

549 W. Randolph St., Chicago 6, Ill. Phone STate 7444



DESIGNERS WELCOME ALUMINUM BRAZING

Before discovery of the way to braze thin aluminum tubes intimately to aluminum header plates and shells, designers of heat transfer units were limited to use of copper in conventional shapes unless they reinforced the structurally-weak copper. That's because soft solder used with copper — even at its best relatively low in resistance to temperature, pressure, vibration and shear — can't stand the uneven stresses resulting from departure from conventional shapes.

NOW DESIGNERS HAVE NEW SCOPE

Clifford's discovery of aluminum brazing gives designers greater scope in planning the shape of heat transfer equipment. That's because:

1. All-aluminum units save ⅔ the weight of copper in the same size and shape.
2. Heat-treatable aluminum alloy tubes stand up under temperatures which gradually anneal and weaken copper.
3. Aluminum alloy brazing material is several times higher in resistance to temperature, pressure and strains than soft solder.

So it's easy to see why USAAF designers gave several shapes of Clifford Feather-Weight Oil Coolers and Coolant Radiators a chance to make good in several types of aircraft.

LOOKING AHEAD

Right now Clifford's production is devoted exclusively to war work; but inquiries and suggestions about post-war automotive, heating, cooling and ventilating applications of all-aluminum heat-transfer units will be welcomed. *Clifford Feather-Weight . . . Save ⅔ the weight . . . same size and shape.* Clifford Manufacturing Co., 563 E. First St., Boston 27, Mass.

IN HYDRAULICALLY-FORMED BELLOWS alloys are chosen with care

Pure metals and many alloys are unsatisfactory for bellows because they lack the necessary spring properties when cold-worked.

A hydraulically-formed bellows — made by forcing a cold tube between the plates of a collapsible metal die by internal hydraulic pressure — requires a metal of good deep-drawing properties and reasonable resistance to corrosion.

80-20 BRASS IS BEST

A brass consisting of 80% copper and 20% zinc is the best alloy because it has excellent deep-drawing properties, is not readily subject to "season cracking", receives required spring-action from cold-working.

PHOSPHOR BRONZE ALSO GOOD

Next in importance is phosphor bronze containing essentially 95% copper and 5% tin. It has properties similar to brass and is more resistant to corrosion. Being higher in cost, it is restricted to specialized cases.

SPECIAL ALLOYS AVAILABLE

Where resistance to corrosion is more important than resistance to mechanical fatigue, copper-nickel series alloys have been successfully used for bellows in hot water systems and high pressure steam devices.

CLIFFORD HAS ALL THE FACTS

Clifford, first to produce hydraulically-formed bellows for industry, has kept abreast of progress in metals . . . and is therefore equipped to supply you with these uniform, pretested bellows in all practical alloys . . . either alone or in highly engineered assemblies. For proof that Clifford is *First with the Facts on Hydraulically-Formed Bellows*, write: Clifford Manufacturing Co., 563 E. First St., Boston 27, Mass.

CLIFFORD *Feather-Weight* **OIL COOLERS AND COOLANT RADIATORS**

HYDRAULICALLY-FORMED BELLOWS HYDRON Metal Bellows

A FEATHER-TOUCH ...AND 400 HORSEPOWER BRAKES GO ON

By B. M. IKERT
Service Editor
THE AMERICAN AUTOMOBILE

POSTWAR motor car advertising will no doubt stress once more the great packages of power under the hoods of vehicles fresh from the production lines.

But, by and large, they'll probably forget about the over 400 horsepower brakes that will be called upon to bring these vehicles to a safe, smooth and quick stop — if necessary — and do so with no more energy than that of a child's foot on the brake pedal.

Sure, the American public wants performance when it tromps down on the accelerator pedal. It likes that feel of reserve power.

But it's just as important — and indeed, probably more so — that there be power to slow down or stop the motor vehicle once it has been placed in motion.

Present-day brakes can slow down or stop a motor vehicle very fast. And, yet, rarely do you ever find anyone boasting about the horsepower of the brakes — horsepower far in excess of that in the engine.

First of all, there is stored up in a moving motor vehicle a tremendous amount of energy. This is energy of motion or what we learned at school in the study of physics as "kinetic energy". Slowing down or stopping of the vehicle is done by the brake mechanism wherein the brake lining rubs against the brake drums of the wheels. This process changes the kinetic energy or energy of motion into heat energy.

If the weight of the moving car is doubled the kinetic energy also is doubled, at all speeds. There is, therefore, twice as much energy of motion to change into heat energy every time the driver of the car slows down or stops the vehicle. The same ratio holds for all changes in weight. If there is three times as much weight to be stopped, there is three times as much heat to be dissipated by the brake drums. And so it goes.

All of us know that motor cars of postwar days will travel at high speeds again and be able to stop safely from these high speeds. Now, when one figures how fast stops may have to be made, several very important factors come into the picture.

A motor vehicle possessed of good brakes can be brought to a stop easily in 4 seconds from a speed of 60 miles per hour. That means the vehicle will stop in a distance of 176 feet. It is quite remarkable when one stops to think about it that the weight of a car can be brought to a complete standstill in four seconds from a speed of 60 miles per hour.

It is still more remarkable when it is realized how powerful modern brakes are considered from the standpoint of how long it takes the engine of a motor vehicle to bring it from a standing start up to a speed of 60 miles per hour. There are a lot of cars in which this cannot be done in less than 30 seconds. As a matter of fact there probably are not many cars powerful enough to be able to do this in much less time than 20 seconds. However, even 20 seconds means that it takes 5 times as long as the 4 seconds needed by the brakes to bring about the same change in speed.

Horsepower of motor cars has been steadily climbing and present engines and those to come may be anywhere from 60 to over 100 horsepower. Let's take 85 horsepower as typical of most of them. With the brakes being at least five times as powerful as the engine, it is safe to say that the brakes on our cars build up at least 400 horsepower. In many cases it will be well over this figure.

Now, in bringing a fast moving motor vehicle to a stop by bringing this tremendous horsepower into action requires a certain amount of effort and time on the part of the driver. The average driver consciously or unconsciously, knows when he is going to apply the brakes. The interval from the instant he thinks about it to the time his foot changes from the accelerator pedal to the brake pedal, is known as "reaction" time. This reaction time naturally varies with different individuals. Some are slow thinkers — others have a lightening-like mind and are much more agile in their actions. Reaction time may vary from a fraction of a second to as much as two seconds.

Two seconds isn't much time. But when you translate it into terms of distance traveled by a fast moving motor vehicle it becomes tremendously important. It will become still more important in post war driving since new cars promise to be fast and highways once more will be dotted with a driving public anxious to shake off the shackles of several years' restrictions.

Supposing the reaction time of a driver is ¾ of a second and circumstances force him to stop the car going 60 miles per hour. At this speed the car covers a distance of 66 feet driving during ¾ seconds time. But remember this is only the "action" time. The brakes still have to be applied to stop the car. That is, the reaction time plus the braking time equals the actual time to bring the car to a stop. If the brakes on the car are 50 percent efficient, let us say, we would get substantially the following:

	TIME	DISTANCE
Reaction time	.75 seconds	66 feet
Braking time	5.45 seconds	240 feet
Total	6.20 seconds	306 feet

So, we see that the car would travel 306 feet from the time the driver thought about applying the brakes until the car actually came to a stop. Brakes in better condition would, of course, permit of a quicker stop, but with brakes and driver reactions being on the average about 50 percent of the ideal, the foregoing figures probably represent prevailing conditions.

We cannot change the ratio of car speed and distance. At 30 miles per hour a car always will travel 44 feet a second. Nothing can be done to change these figures. But something can be done to cut down the lag of time in applying brakes so that no matter how tired the driver a light touch of the pedal effectively and easily stops the car. Instead advantage is taken of the common forces such as atmospheric air pressure and the vacuum existing in the intake manifold of the engine in the motor vehicle.

A railroad engineer brings a half-mile long train to an easy stop. His strength does not enter into the problem at all.

Nor should the car driver's strength enter into the problem of stopping his car. Like the railroad engineer the driver with power braking, merely puts his foot lightly on the brake pedal and then, vacuum and pressure go to work for him. These two forces will do it so much more quickly and positively that no driver can compete with them. Besides—and this is important—vacuum and pressure never get tired or confused, no matter what the emergency. All the driver of a well "braked" car need do is give the brake pedal a light touch whereupon the booster action goes into effect so smoothly that the driver is not aware of it.

Power braking with feather touch control will supplant the "leg muscle" act of the driver just as electric starting shelved muscle power in cranking engines.

SIMPLIFIED — EFFECTIVE

feather touch STOPABILITY

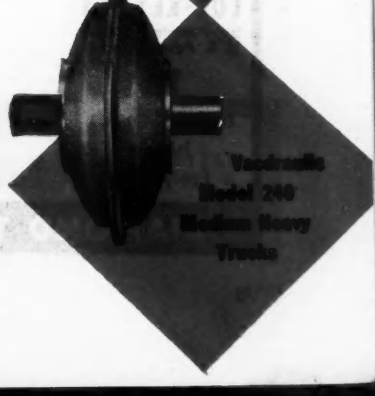
Now you can give the driver of your truck a "break." He deserves it! He needs it! With Vacdraulic feather-touch brake action, accidents will be averted, payload delays measurably cut and time lost in service tie-up reduced.

Vacdraulic — the Brake Power Booster goes into action with a feather-touch pedal pressure. Vacdraulic gives any good hydraulic brake system the margin of split-second stopability which compensates for that critical distance traveled due to reaction lag, traffic distractions and leg fatigue.

Vacdraulic — the power braking booster — is an engineered, proven, and dependable unit. It gives any hydraulic brake system the step-up necessary to bring the vehicle to a quick, smooth stop.

* * *

May we send you complete details?



VACDRAULIC

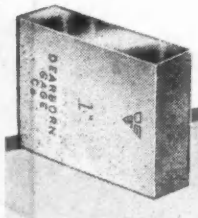
THE BRAKE POWER BOOSTER

KELSEY - HAYES WHEEL CO., DETROIT, MICH.

Sold to Automotive Distributors by

EMPIRE ELECTRIC BRAKE CO., Newark 7, N. J.

VACDRAULIC is a Trade Mark of Empire Electric Brake Company



Send us your gage blocks for a complete measurement check

PROMPT RETURN

Take advantage of Dearborn Gage Company's complete inspection service for all types of gage blocks. Just send your gages to us and they will be inspected immediately and returned to you within 10 days from the time received by us.

Accurate calibrations are made (after the removal of high spots or burrs) in our temperature controlled inspection room, at 68 degrees Fahrenheit.

Where gage blocks are not badly worn and a more complete calibration is required, end and center measurements are made on rectangular type gage blocks and at the center of each side of square blocks.

CHARGES

2 types of inspection now available.

THE "W" (OR WORKING) CHECK:

Twenty five cents for each block smaller than one inch and twenty five cents for each additional inch or fraction thereof.

THE "I" (OR INSPECTION) CHECK:

Fifty cents for each block smaller than one inch.

Fifty cents per inch of block or fraction thereof of longer blocks.

REPLACEMENTS

When you send in your gage blocks for inspection it is very practical to give us specific instructions to replace any of your gages which we find to be worn beyond a certain tolerance. This specific tolerance is, of course, to be determined by you. You may also wish us to replace certain gages which have become damaged in some manner.

DEARBORN GAGE Company

Certificate of Inspection

Reproduced above is a sample of a certificate of inspection, stating the specified size of each block measured and the actual measurement or variation from normal size.

DEARBORN GAGE CO. 22037 BEECH STREET DEARBORN, MICHIGAN

Originators of Chromium Plated Gage Blocks

Compressibility Effects

(*Continued from page* 21)

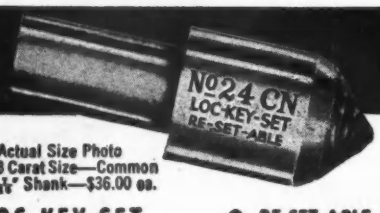
served where the natural pullout tendency was so great that the pilot could not prevent recovery.

The speed of sound in air depends only on the temperature. It is proportional to the square root of the absolute temperature. It is about 764 mph at 60 F. and about 670 mph at —60 F. This is very detrimental to aviation because at higher altitudes, where the air has low density and offers less drag at a given speed, the speed of sound is lower. This makes it much easier to reach the critical Mach number at high altitude.

The air speed varies while the air is passing over an airfoil. Near the stagnation point on the leading edge, the velocity is very small. The air then accelerates to a speed greater than the speed of flight while it flows over the thick portion of the airfoil. It resumes a speed near to the speed of flight at the trailing edge. The purpose of an airfoil is to produce lift and in order to do this, the air must flow over the top surface at a speed greater than the free stream speed. (Note: We think of the airplane as at rest with the air flowing past it.) At high speeds this extra speed over the thick portion of the airfoil may be sufficient that the speed of flow approaches or exceeds the speed of sound. We thus see that the critical Mach number is less than one. The value of this critical Mach number can be raised by making the airfoil section thinner. However, there is a required minimum thickness which will produce the necessary lift and which will have the structural strength to withstand the applied forces.

Propellers are affected by compressibility. The tips of the blades are moving at a speed very close to that of sound. One of the recent changes for high altitude operation is the "paddle-blade" propeller. It has a very

(*Turn to page* 100, *please*)



Actual Size Photo
3 Carat Size—Common
¼" Shank—$36.00 ea.

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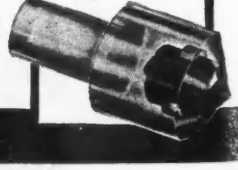
(Trade Marks Registered)

Equip Now with "RE-SET-ABLE" Diamond Tools on Your Precision Grinding Production Line



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by Patented Process
U. S. Pat. 2,351,741

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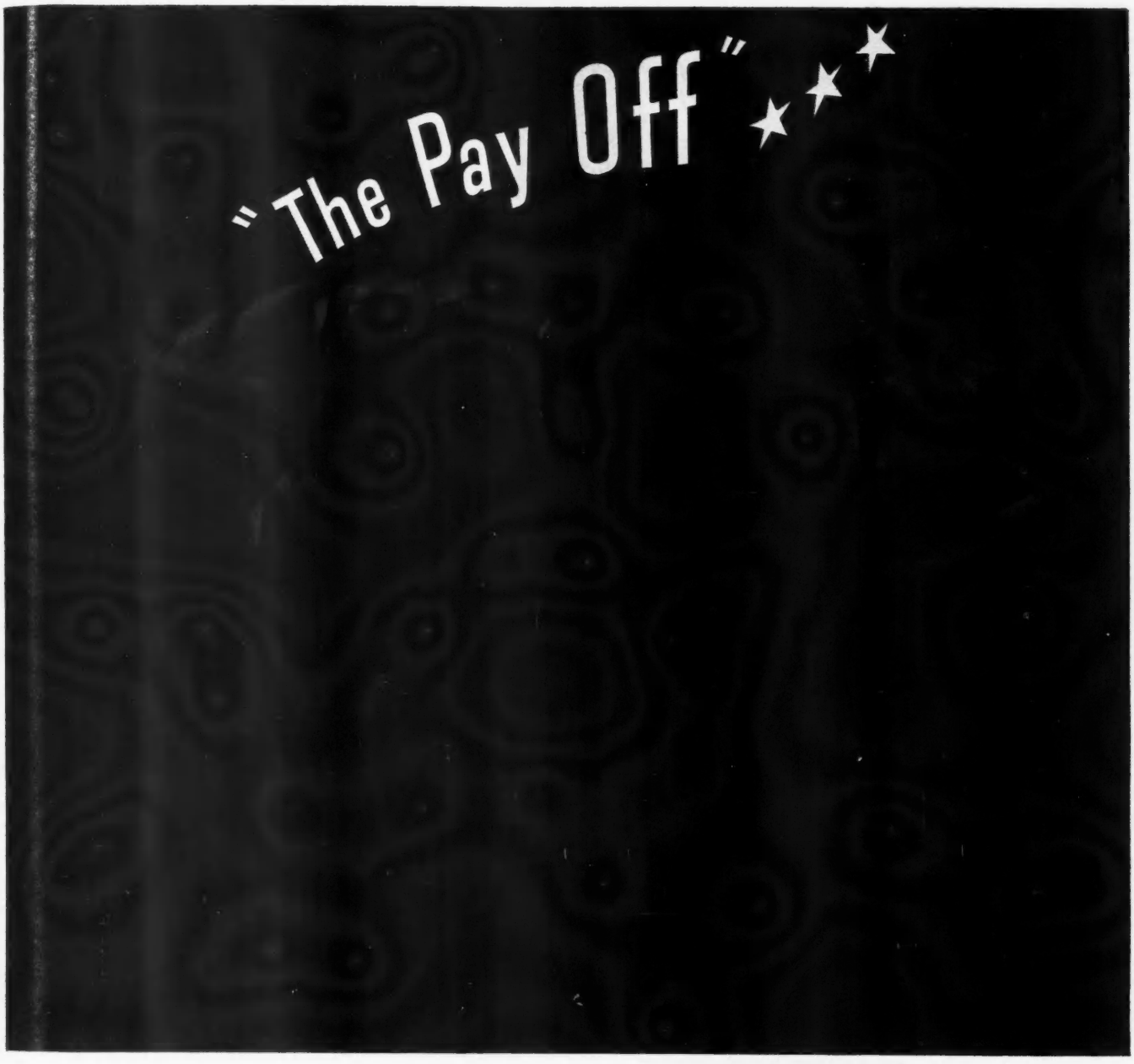
Jobbers Everywhere

● **RE-SET-ABLE** adds to life of your diamond . . . More work per carat. Exclusive patented setting is tender to the diamond . . . Holds firmly . . . Protects from damage . . . Guards against breakage.

No. 24 CN RE-SET-ABLES are now selling in 100 lots. Ask for easy No. 4 Catalog and Grinder's Instruction Card. Shows sizes to fit your machines. Tools backed by service unequalled.

All diamonds are LOC-KEY-SET for immediate shipment . . . Tools numbered in units of ⅛ carat (No. 1 size) and lettered to denote quality of diamond and style of mounting . . . 3 grades — Common (C), Medium (M), Select (S). (24-hour resetting service $1.00 postpaid.) Bigger stones in C grade are genuine economy in diamond use. For large wheels we recommend No. 60-CN.

DIAMOND TOOL COMPANY, Not Inc. SHELDON M. BOOTH, Pres. 938 E. 41st Street CHICAGO 15, Ill.



This boy tried hard—but he lost.

He was searching for something. In his simple way, he believed he'd find it in the prize fight game. But he didn't seem to have the Big Plan thought out, or something. He lost.

It's that way with people, with organizations, with nations. To survive, we've got to do a lot of thinking. This is a time for it—individually and collectively.

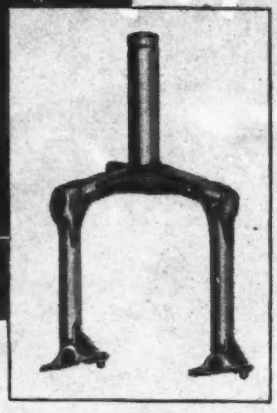
Because this is the Second World War. A Third might reduce all of us, our hopes, our essential rightness, to a pile of ashes. This is a time for straight thinking.

We at Bryant have been trying to see things straight. Some time ago we realized that as essential suppliers to industry we had better have a pretty solid plan. A plan based upon search and research—upon a knowledge of new and better methods of building the needed things of peace—upon service to all comers who might use our specialized knowledge to build a better America. That seemed a good plan, and it has been.

For today, our engineers are working with the engineers, designers and planners of scores of successful American businesses, and many new ones, large and small—helping them to plan now, conversion of their plants, skills and machines to all-out production of new and better products for a prosperous peace.

If you are a manufacturer, we invite you to call us in today.

BRYANT CHUCKING GRINDER COMPANY SPRINGFIELD VERMONT, U.S.A.



A BOMBER'S "FEET" DEPEND ON THIS FORK!

One of the highly essential precision items produced by the Welded Tubular Assembly Department of Aircraft Mechanics, Inc., is the "Beech Fork," used on many bombers serving our armed forces.

All tooling necessary for large quantity manufacture of the "Beech Fork" was produced in the Tool and Jig Departments of Aircraft Mechanics, Inc.,—and schedules have been maintained as promised.

Our Engineers, Designers and Production Crews now are engaged 100% in the production of this and other highly essential welded tubular assemblies for many of the major aircraft manufacturers. In addition, our Airforge Division is producing tens of thousands of high tensile steel forgings for more than fifty aircraft manufacturing firms.

If you need additional facilities for the manufacture of welded tubular assemblies or forgings, it is probable that we can help you. Write us, today, and we will send full information, immediately.

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wide blade with a thing section, and it is of smaller diameter than was formerly used for the same horsepower. The thin section has a higher critical Mach number but lower lift coefficient than the regular section. The shorter blade reduces the tip speed. In order to absorb the same power with a thinner section and shorter blade a wide section is required.

The quantitative prediction of the behavior of an airfoil at high speed has not been very successful up to the present time. The commonly used correction factor is that of Glauert, $\frac{1}{\sqrt{1-M^2}}$ where M is the Mach number. This factor represents the ratio of the compressible and incompressible coefficients. It is reasonably accurate at the lower Mach numbers but does not agree with experiment at the critical Mach number or above. It is largely on the basis of this equation that the speed of sound is selected as the limiting speed. (Note: if M is greater than unity the result is the square root of a negative quantity.)

Von Kármán and Tsien obtained an equation which is a better approximation than the Glauert equation. It is usually given in the form

$$C_{P_M} = \frac{C_{P_o}}{\sqrt{1-M^2} + \frac{M^2}{1+\sqrt{1-M^2}} \cdot \frac{C_{P_o}}{2}}$$

where C_{P_o} represents the incompressible fluid pressure coefficient and C_{P_M} represents the compressible fluid pressure coefficient. To find the pressure coefficient first find the difference between the free stream static pressure and the static pressure at the point in consideration. Then divide this difference by the free stream dynamic pressure. This quotient is called the pressure coefficient. The incompressible pressure coefficient C_{P_o} is obtained at low speed since air then acts similar to an incompressible fluid. The com-

(*Turn to page* 103, *please*)

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pressible pressure coefficient C_{P_o} is found at speeds sufficiently high that the changes in pressure cause appreciable changes in the air density.

C_{P_M} and C_{P_o} are used as coordinate axes for a curve representing the air conditions in its flow over an airfoil. The curves are similar to those shown in Fig. 1. The curve for the low Mach number represents the condition in which the air velocity does not approach the speed of sound at any point. The curve for the high Mach number represents the condition where the local air speed is greater than the speed of sound during a portion of the flow over the airflow. The lower left hand end of the curves represents the stagnation point. the origin represents free stream conditions and the upper right hand quadrant represents a local air speed higher than the free stream speed.

At point *B* the local speed is equal to the speed of sound. At *A* the maximum speed without shock has been reached and if this speed is exceeded a shock zone will be formed at some place down stream. The point *C* represents the peak velocity and following it the speed drops almost instantly to a subsonic speed. This is the shock zone.

The above explanation is further illustrated by using the airfoil chord as the abscissa and plotting both $_M$ and C_{P_o} as ordinate, as shown in Fig. 2. Points *A*, *B*, and *C*, are shown so that they correspond with the similar points of the previous diagram.

An equation recently published by L. M. Greene appears to give a much better approximation of high speed flow conditions, than any previously published. New interpretations of this equation by Consolidated Vultee engineers indicate that reasonably accurate predictions of compressible flow including shock can be made.

With our present knowledge of compressibility modern airplanes have almost reached the limiting speed. At Mach numbers of 0.6 to 0.7 shock zones begin to form at some points and the

(*Turn to page* 104, *please*)

A SINGLE
CENTRAL
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FITS OVER 100 DIFFERENT HOSE SIZES

● The Wolverine of the North Woods is a little fellow, but he can lick almost any size animal. The *Central ALL-SIZE Hose Clamp* likewise is able to take on any size—for just *one size* in the *ALL-SIZE* fits over a hundred different hose sizes. (The standard length, for example, fits any hose from 1" to 3" O.D.)

Thus the *ALL-SIZE* eliminates the need for different size hose clamps. And it is powerful enough for all production and service requirements. It is easiest to use in hard-to-get-at-places; has fastest clamping action; goes on or off in a jiffy, without disconnecting the hose line; has plenty of take-up, even on synthetic hose; is rustproof, leakproof, self-locking; can't strip or loosen . . . standard for U. S. combat vehicles.

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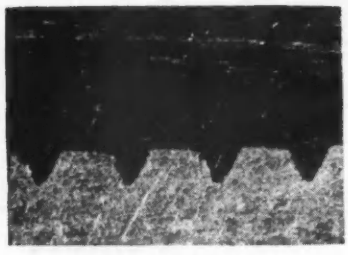
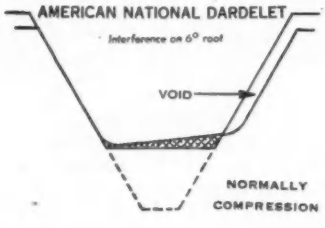


AMERICAN NATIONAL DARDELET THREAD

AMERICAN NATIONAL THREAD



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drag increase is so great, for a few miles per hour extra speed, that we have not the power available to overcome it. There have been a few attempts to solve the problem of high speed by increasing the power and trying to overcome compressibility by brute force. The results have been that the tail came off for no apparent reason, or there were other structural failures caused by extremely large forces. In other cases the stability and control were such that it was impossible to control the airplane at such high speeds.

In high speed dives the effects of compressibility on stability and control constitute a very serious and incompletely solved problem. In some cases there is great stability and no control with the result that the pilot is unable to recover from the dive. At lower altitude, where the increased drag reduces the speed of the dive and where the speed of sound is greater, normal control may be recovered. In other airplanes a critical speed is reached in a dive at which a sudden recovery is produced. The pilot is unable to control or prevent this sudden recovery and the result is excessive forces which may cause structural failures.

Jet propulsion appears to be one solution to the problem of compressibility and propellers at high speed. It is, at present, the only satisfactory way of producing thrust at supersonic speeds. However, the power plant problem is only one of many. Before supersonic flight is possible it is necessary to design airfoils and fuselages and control surfaces which will provide the necessary lift and control at supersonic speeds. The problem is further complicated by the requirement that lift and control be provided by the same airfoils at subsonic speeds during the acceleration to high speed flight.

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Nationally known industrial research organization in Chicago has opening for graduate Chemical or Mechanical Engineer, age 30 to 40, to assist in supervising research on internal combustion engines, engine fuels and lubricants using Diesel and gasoline units. Work is essential with definite and extensive post war prospects.

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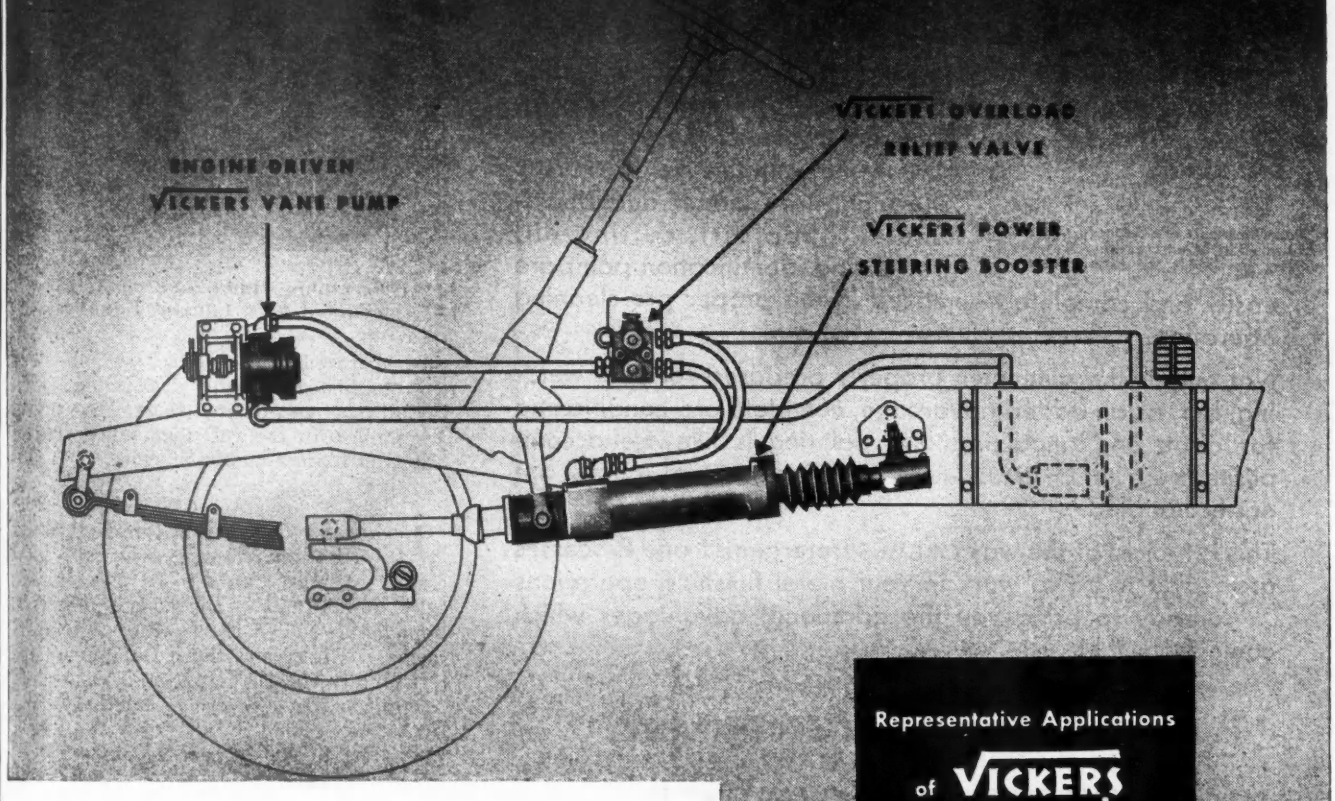
Another Important Advantage of

HYDRAULIC POWER STEERING



Requiring only a minimum of space for installation, the Vickers Hydraulic Power Steering System can be applied to most existing hand steering mechanisms with a few simple alterations. The separate power cylinder (booster) can be located where it does not interfere with other apparatus and where the power will be applied directly to (and in line with) the drag link. No additional space is required at the end of the steering column where space is usually at a premium.

Other important advantages of Vickers Hydraulic Power Steering are: effortless, positive and shockless steering . . . road shock thrusts are transmitted to the frame of the vehicle instead of to the steering gear . . . automatic overload protection . . . reduced operator fatigue . . . greater road safety . . . automatic lubrication . . . and 15 years of successful operating experience. Bulletin 44-30 gives complete information about Vickers Hydraulic Power Steering; write for a copy.

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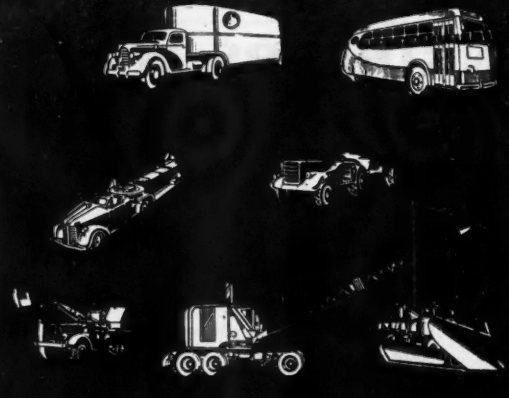
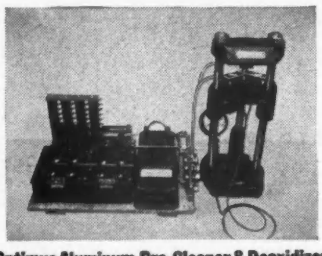
Representative Applications of VICKERS HYDRAULIC POWER STEERING



DOES THIS SPECIFICATION

DUAL PROBLEM:
1. To produce low surface resistance on aluminum preparatory to spot welding.
2. To place aluminum in condition for alrok and anodizing and painting.

RESULTS DESIRED:
Smut-free surface.
Oxide removed using a cold solution.
Negligible weight loss.
Minimum machine adjustment.
Minimum handling.



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WHILE THIS "specification" may seem to establish pretty stringent requirements, these are adequately met with the use of OPTIMUS Aluminum Pre-Cleaner and Deoxidizers. Shop dirt, cutting oil, grease and identification paint are easily and completely removed in the proper pre-cleaning operation.

Not only is the aluminum properly prepared for spot welding, but, as an added advantage, complete pre-conditioning for alrok and anodizing and painting is likewise accomplished. With OPTIMUS methods all classes of alloys are easily handled.

This is typical of the way OPTIMUS Detergents* and Processes are ready to go to work in your metal finishing operations . . . ready to bring you the additional advantages which come from their use.

*Available in Alkaline, Acidic, Solvent and Emulsion types.

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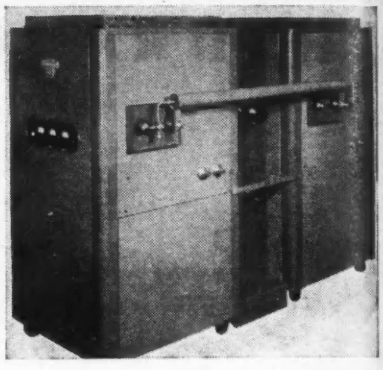
OPTIMUS DETERGENTS FOR INDUSTRY

New Production Equipment

(*Continued from page* 39)

conductors) requires only the connection of the equalizer to the output terminals of the generators. An additional inter-connection is made between the power sections of the generators to give electrical stability. The equipment can



Thermonic induction generators coupled by a Coaxial Equalizer

be operated single phase, two phase or three phase, making it possible to install the equipment from any power supply with the full load power factor at approximately 90 per cent.

EXACTONE TOOL & DIE CO., Hollywood, Cal., is introducing a brush-backed sanding wheel known as the Sand-O-Flex. The device consists of a central magazine which houses the strip abrasive. Eight of these strips extend through the housing and are held against the work by bristles. The bristles cushion the abrasive, making it possible to get in and around corners, hollow and fluted surfaces, and small openings.

The body and cover of the Sand-O-Flex are cast from Zamak. Overall diameter (including brushes) is approximately 8 in. Weight fully loaded is about 2¾ lb. Normal loading contains 20 ft. of abrasive and reloading is

(*Turn to page* 108, *please*)

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An aggressive Midwest company of long standing has opening for experienced engineers interested in good paying, permanent position. Applicants must have good engineering background. Some sales ability helpful but not required. Write us in confidence, giving full experience and other data which will help in making our selection. Snapshot may be included but will not be returned. Selected applicants will be invited to visit us at our expense.

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This book "Beyond a Shadow of a Doubt" will tell you more about our Optical Comparators and what they are doing.

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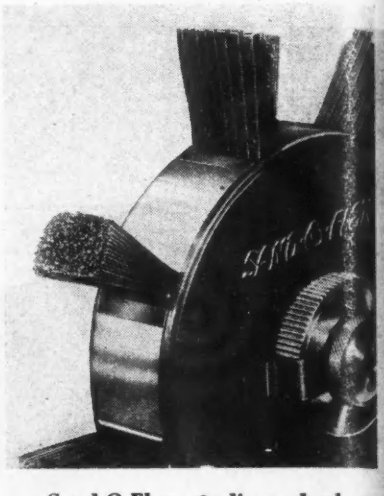


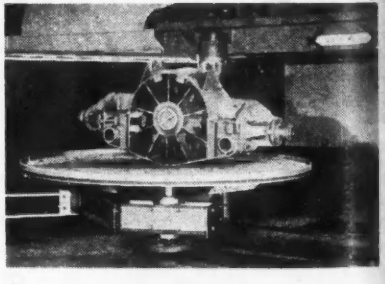
Sand-O-Flex sanding wheel

done by unscrewing the serrated nut and removing the cover. Abrasives of various grits and grades are supplied for use with the sander.

SEVERAL models have been added to the line of Wheelabrator swing tables made by American Foundry Equipment Co., Mishawaka, Ind., to suit the needs of industries having a moderate production covering a wide range of work to be cleaned. The Wheelabrator swing table, which utilizes the Wheelabrator airless abrasive blasting unit, extends the speed and economy of airless blast cleaning to a wide range of intricate or irregular shaped work.

Four sizes of this blast cleaning machine are now available with sizes of

(*Turn to page* 110, *please*)



Wheelabrator swing table

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Ingenious New Technical Methods

Presented in the hope that they will prove interesting and useful to you.

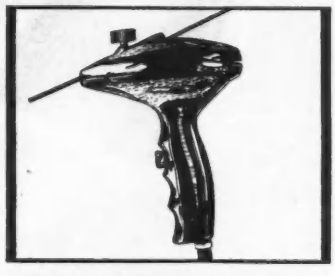
Highly Versatile "Pencil Weld Gun" Welds Cold... Corrects Flaws and Defects ... Saves Man Hours, Materials

The Pencil Weld Gun, used with its Vibra-Weld Transformer, offers simplicity and versatility never before known in the industry. Equally effective in correcting flaws and defects in both ferrous and non-ferrous metals—for welding cold, without setting up stresses or crystallization.

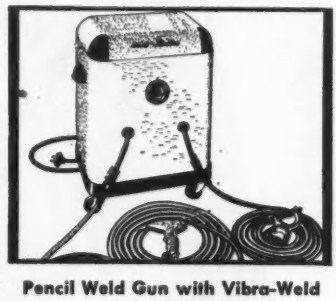
Simple in Operation, the Pencil Weld Gun requires but a few moments' practice to achieve results formerly unobtainable with any method. Utilizing a combination of air, high amperage and low voltage, the weld never exceeds 125° to 130° F. The gun uses a pure aluminum or nickel rod, which is applied directly to the defective area. When the surface has been finished and polished off, it is impossible to detect the repair. Easy to use, as gun peens and welds simultaneously. The Pencil Weld Gun and Vibra-Weld Transformer can be used wherever 220 volt single phase electricity and air outlets are available.

Unavailable, however, is Wrigley's Spearmint Gum. As the makers of Wrigley's Spearmint are unable to continue manufacture of the product up to their quality standards under present conditions, the only unqualified protection they can give to the consumer and the dealer alike is to keep the Wrigley's Spearmint wrapper empty. While they advertise this empty wrapper, none is being made and any found on the market is old production of a perishable product.

You can get complete information from
Mid-States Equipment Company
2429 South Michigan Avenue, Chicago 16, Illinois



Close-up of new Pencil Weld Gun



Pencil Weld Gun with Vibra-Weld Transformer

Z-66

the single work table being 24, 66, 72 and 86 in. in diameter. Operation of the four units is essentially the same, the machines varying only in minor construction details and number of Wheelabrator units utilized.

Work to be cleaned is placed upon a rubber-covered work table which is mounted on the door of the blast cabinet. As the door is closed, the work table swings into the cabinet underneath a Wheelabrator airless blast unit. While in this position the table is rotated at a predetermined speed. The Wheelabrator unit whips a continuous stream of abrasive down upon the rotating work to the full width of the table so that all surfaces are uniformly blasted to a bright, clean finish.

General Electric Air Conditioning Department

The air conditioning department has been established as one of the six major operating departments of the General Electric Company. Operations pertaining to heating, air conditioning, and commercial refrigeration have previously been the responsibility of the company's appliance and merchandise department. The new department will have its headquarters at Bloomfield, N. J., and George R. Prout has been designated as general manager.

Postwar Production of Helicopter Transmissions

Manufacture of helicopter transmissions and other aircraft gearing will be continued after the war by the Detroit Gear division of Borg-Warner Corp. Anticipating a substantial demand for the parts for use in commercial and private planes in the postwar period, the company has determined to remain in the aircraft gear production field because of its successful experience in the output of these parts during the war.

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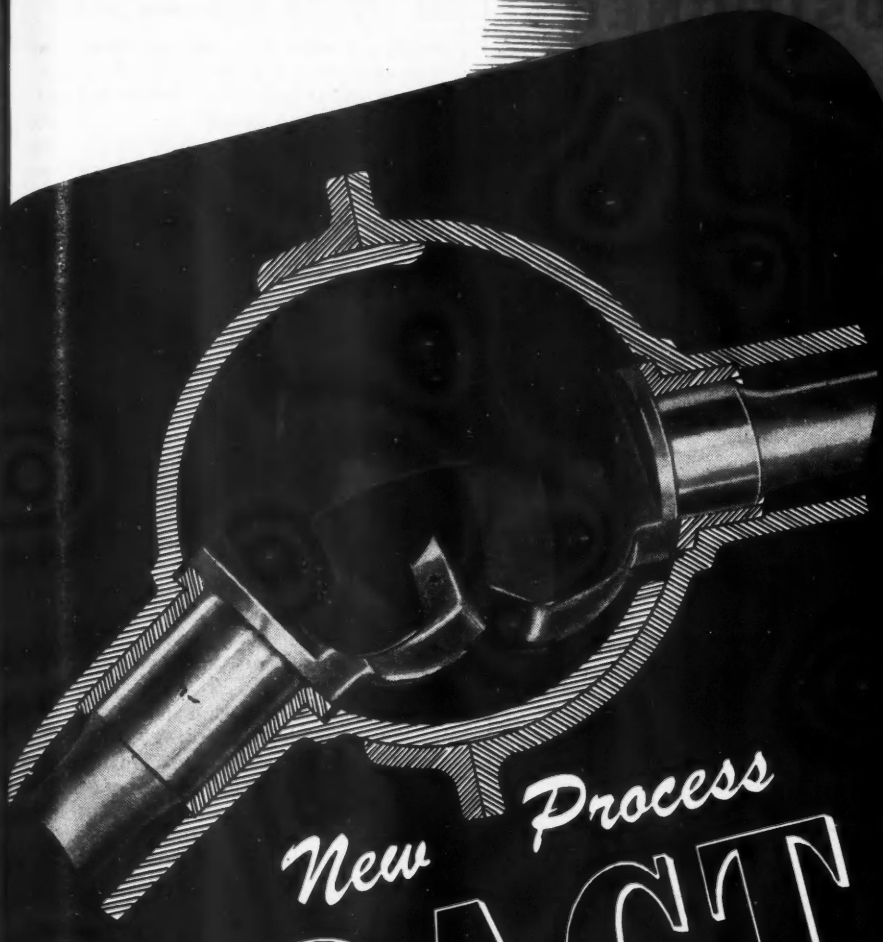
Designed for AIRCRAFT, MARINE, JEEP, TRUCK, TRACTOR AND AUTOMOBILE PUMPS
CRANE PACKING COMPANY, 1818 CUYLER AVE. CHICAGO 13, ILL.

MAKES FRONT-WHEEL DRIVES EASIER TO STEER BECAUSE:



Constant Angular Velocity...

Uniform Power Flow...

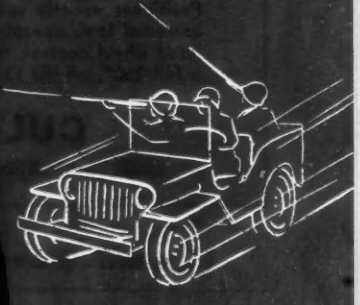
Uniform Traction...

Less Tortional & Lateral Vibration

New Process

TRACTA

CONSTANT-VELOCITY UNIVERSAL



● Assuring constant velocity over wide steering angles and under heavy loads, the New Process TRACTA universal eliminates the traction losses, backlash and high-frequency vibration of ordinary Cardan joints. Light and compact, it practically nullifies centrifugal and gyroscopic forces, making steering firm, responsive and positive at high speeds and under heavy torques. There are no nuts or pins to assemble or shake loose. The four simple parts slip together handily, greatly reducing assembly time and cost.

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1,200 lb.
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20,000 lb.
30,000 lb.

Write for Bulletin WP-22

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Cutbacks in Contracts

(*Continued from page* 44)

duction needed for the Japanese war is assured, the supporting civilian economy is organized and functioning satisfactorily, and small businesses are protected from a "squeeze out" after controls are lifted. "It is entirely possible," he said, "that WPB will close up shop before the end of the Japanese war if the production of munitions is assured in sufficient quantity to finish the job."

"The exact number of controls that will be dropped within hours or a few days after V-E day has not been determined," he stated, "but it probably will be about a third of those now on the books. Others will follow as soon as possible until only those involving critical items are left, and even these will go at the first moment they are no longer needed." A major WPB objective, Tiedeman said, is the speediest possible reconversion, and the agency is convinced that the best way this can be accomplished is by giving industry a free hand rather than by a planned economy.

There is no question in the minds of WPB heads, according to Tiedeman, that after a period of adjustment during the transition to a one-front war "combined operations" of war and production can be carried on so that output of civilian goods would approximate prewar levels.

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